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# “Our guarantee to our customers is the industrialisation of their products”

## Interview with Tone Konda and Jože Štupar, Directors of Keko Equipment

**In the past few years, the manufacturing activities at Keko Equipment have expanded greatly, including the expansion of their equipment catalogue offering a wider range of machines used in various industries. What is the basic strategy of the equipment catalogue expansion?**

JŠ: The technologies of our Company's machines are based on a common platform: tape casting, screen printing, stacking, laminating, green cutting, etc. Our activities are based on manufacturing the machines that help our customers industrialise new products, and also to automate existing lines. For new products we have to consider our customers' needs and the possible technologies that can be applied. Usually we have to work closely together to find the best solution.



TK: Our machines are designed as functional units, which can be used for making different products. For instance, the manufacture of electronic components is, in a certain phase, very similar to the manufacture of SOFC fuel cell or piezo actuator. It's then up to our flexibility, knowledge and capabilities to apply this for new product

making. The manufacturers of passive electronic components are still our main customers; however, new areas are opening up. Photovoltaics, the field of alternative energy, for instance, is a very interesting area lately, since applicable technologies are being searched for and many issues are still economically inefficient at the moment; however, there is no doubt, that this will be a significant activity in the future.

JŠ: One of the problems is related to one of our specialties - screen printing of electrodes. The new research in manufacturing solar cells in accordance with new technologies is still not decided and slightly non-defined, therefore, we are carefully following what happens on the market.



**The opening of new markets also poses commercial questions about the company's presence on the global market. How do you follow these challenges?**

TK: We are not afraid of these challenges. We cover various markets and industrial branches with a strong and professional network of agents. They cover Europe, Americas, Asia, i.e. all the important markets in the field. We also want to offer best service to our customers, one recent example is the fact that we employ, together with our agent in China, two engineers who will be in charge of servicing our machines and providing technical support to Chinese customers. We are now in the starting phase of getting established in the Japanese market; the big Russian market is also new for us. Just recently, we signed a dealer contract with the company Ostec in Russia to represent us in this large and quickly developing market. We have a machine showroom right here in Žužemberk and another one in Miami, FL (USA); and we are currently discussing the possibility of opening a showroom in China.

JŠ: These showrooms allow a customer to come to see and test our machines, processes and discuss all possible options. The customer can test their materials on our machines with our support and make samples, prototypes or a trial series of his products.

TK: We receive many inquiries from various industrial branches via our network of agents. Sometimes the applications are not typical; these technologies are even used in the food or pharmaceutical industries.



**Does the basic objective, to solve customers' problems on an individual level, still remain despite the expansion of markets and activities?**

TK: Of course. On one hand we are having big companies, leaders in the global electronic industry, which are completely closed regarding their technology and manufacturing methods; and in the other hand we see companies, which are fully open to work with external suppliers. This is why it is very important to follow trends, have your own development department and listen to the need of our customers. Our strength is in "custom designing" equipment, where we are flexible and fast.

JŠ: As it was already mentioned, it is quite common for us to make a sample or sample series of the products with the customer and their materials. One third of our employees work in development and the majority of the others have to be able to think in a "developmental" way. Almost every product requires a certain adjustment or innovative solution, since we face various developmental challenges on a daily basis. Guaranteeing the high quality of the final products produced in our machines, while using cost effective materials present an additional pressure on us as the manufacturer of machines. There is never real peace and ease here.

**The year 2009 will be remembered for the economic recession and we cannot avoid a somewhat cliché question, how did the recession affect your company?**

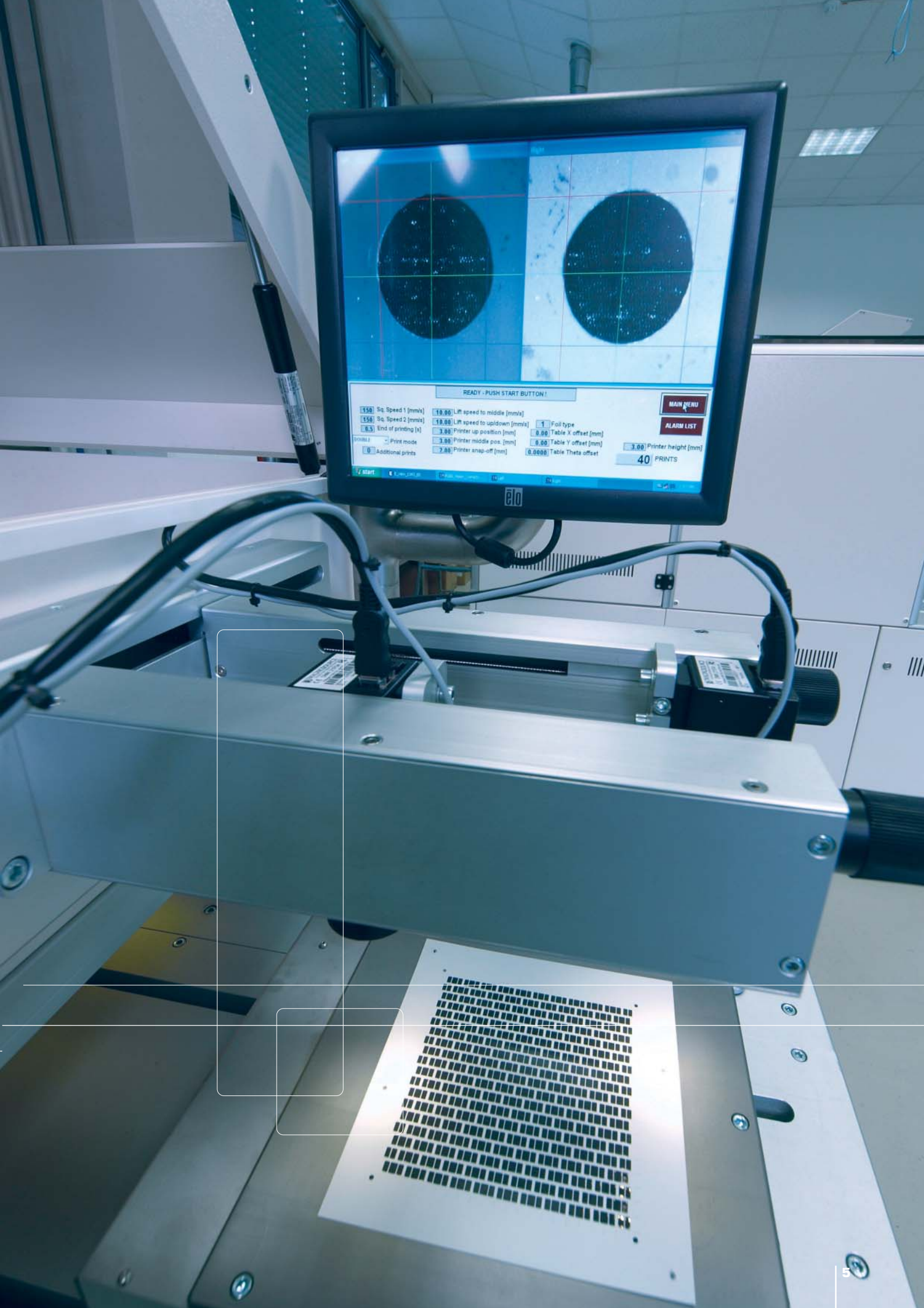
TK: We would have certainly felt a stronger impact of the recession if we had not had our developmental projects; so, we were not greatly affected by the recession. This year is the year of market restructuring. The electronic industry is introducing new products the so-called alternative energy industry application is opening.

JŠ: The recession mostly affected our American and European sales. The Chinese and other Asian markets were less affected. Now investments are being made in high-tech projects, these are very important for us, since we also can offer technology support in such projects and offer "turn key" solutions, in this way our customers can concentrate more in the development and marketing areas, speeding up the return of their investment.

TK: Market changes happen all the time and we have to be prepared for them. What counts most is that we know how to make a machine that guarantees quality and cost effective manufacturing to our customers. This puts us on top, amongst the world's companies that operate in this industry.







# Influences to stacking alignment accuracy in multilayer ceramic components production

In this article I would like to explain couple of facts, which influences to the stacking accuracy.

As machine maker we have often discussion with our customers regarding stacking accuracy especially, if real alignment after cross-section of stack is worse than machine specification.

Basically: **Final stacking accuracy = Machine registration accuracy + Input material influence**

If customer is asking for the machine accuracy, we are talking to him always about machine registration accuracy, as usually we do not have any influence to the customer input material, its properties and accuracy, although these properties influence usually much more, than machine registration accuracy itself.

## What do we mean with machine registration accuracy?

To the machine registration accuracy influences:

- Repeatability carrier palette registration
- Screen shifting repeatability (in case of print on stack)
- Pressing plates flatness and parallelism
- Other mechanical repeatability parameters like, moving accuracy and repeatability of movements which may influence to the alignment accuracy.
- Vision resolution
- Other influences, which can be measured on the machine

All these summarized influences are specified in machine datasheets as machine registration accuracy.

## Material influences:

Which materials and process influence to the final alignment?

If the cross-section of stack through the print is observed than following parameters influence to the stack:

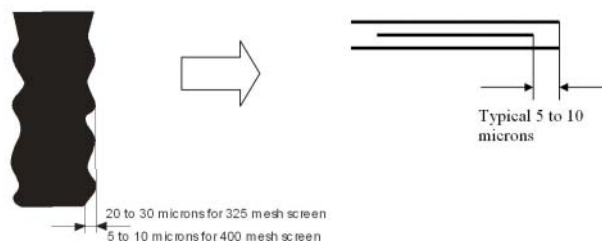
- general printing quality
- fiducial mark print quality (in case of vision alignment on printed marks)
- fiducial mark distance repeatability
- tape properties

In case we are stacking custom printed sheets or tape, we do not have any influence to change performance of the input material.

## To printing quality influences mainly:

### Screens quality

Nowadays 325 up to 600 Mesh screens are mainly used. Depends of product, customer would like to have requested lay-down. In case of capacitor production normally low lay-down, in case let say MLCC production, higher lay-down. Mainly mesh opening, wire thickness and way of screen production influence to the lay down. For low lay-down emulsion and thin mesh is used. If we observe print, using screens made by photo emulsion edge of print is not straight but more according to the picture bellow.



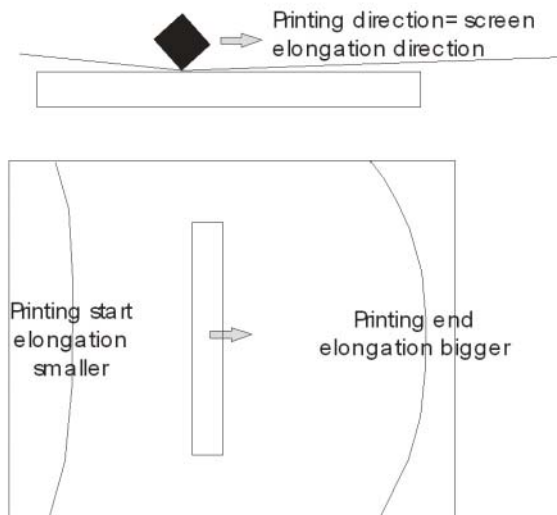
If screens are made by photosensitive foil, this effect is less present, but such screens are mainly not suitable for low lay-downs, because of additional foil thickness.

This effect, if the screens are not extremely bad, it does not have big influence to general alignment.

We call it virtual misalignment, which should be taken in account.

### Screen elongation during printing in printing direction

Screen elongation reflects in phenomena that print is a bit bigger and shifted in direction of print compare to the screen pattern.



What influence to the screen elongation?

- Mesh wire thickness (thin wire, bigger elongation)
- Screen made by foil or emulsion (foil –small elongation., emulsion-bigger elongation)
- Screen frame dimension and stiffness
- Printing area (bigger area bigger elongation)
- Screen tension (new screens less elongation, used screens more elongation)
- Uniformity of screen tension (defines elongation shape)
- Squeegee type (drag or diamond, drag type less and more uniform elongation)
- Squeegee force (higher force more elongation)
- Squeegee straightness (influence to elongation shape)
- Squeegee parallelism against the printed surface. (Influence to the elongation shape)

Normally screen elongation effect is in the range of 10 to 50 microns for screen frame sizes 450 x 450 on 6 x 6 inch printing pattern. Screen elongation effect is almost linearly connected to the printing surface. It does not influence to the individual chip alignment within one batch much, if:

- Printing and stacking direction is same for all prints in a batch

- Printing parameters did not changed during printing

- Printing is done using single screen

Screen elongation has dramatic influence to alignment if:

- Two or more different screens are used producing same batch (LTCC production)
- Print rotation against previous one (either screen or substrate)

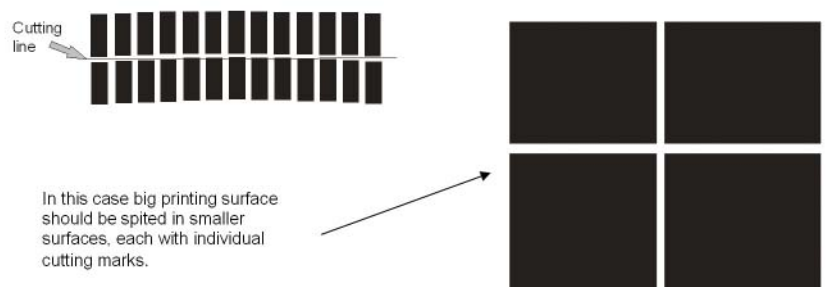
In case of print rotation, the elongation effect is doubled. It is possible to partly eliminate this effect by moving the screen pattern center for elongation out of substrate center. As the elongation of screen is not identical over the complete pattern, it is impossible to align two rotated prints perfectly using screen with bigger elongation tendency.

### Double print

Double print in opposite directions, does not influence much to the alignment but, if this printing method is used, than print is shifted in both directions, what reflects in bigger printed surfaces. If double print is needed, squeegee has to move twice in same direction.

### Other screen elongation influences

Screen elongation causes problems making small precise components on big printing surfaces. Due the screen elongation lines of printed elements are curved. This makes problems during the cutting.



### Printing paste influence to print quality

What basic properties printing paste should have, for trouble free screen-printing?

- Not drying on the screen

If paste dries quickly, edges of pattern get dry quick. It reflects in smaller printed area. Screen has to be cleaned often. After cleaning, printed area is bigger. Often screen

cleaning reflects in not uniform print areas, which causes misalignment look, after cross-section is done. Lay down vary from print to print.

- Drying

Printed paste has to dry fast at low temperature. High drying temperatures (above 80 deg.C) and long drying times (above 4minutes) reflects in tape shrinkage and misalignment later on.

### Ceramic tape

Compatible tape properties with the stacking printing process are most important for good alignment and smooth process flow. What tape properties as most important to be compatible with printing and stacking process?

- Tape permeability

During stacking tape is pressed on to pervious one. If tape does not have air permeability, air will trap between the layers (like between plastic foil). It reflects in bubbling of the tape after pressing, higher stacking forces for taking, distortions, printing problems on bubbled surface and at the end delimitations on final products. Ceramic tapes on Mylar must have higher permeability compare to freestanding tapes.

- Tape taking properties

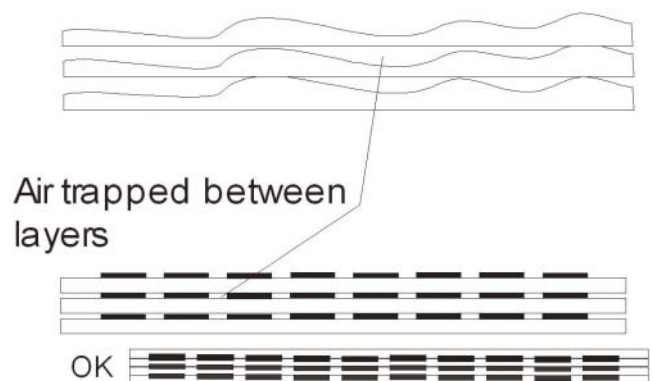
General taking properties: Tape taking pressure should be bellow 10N/mm<sup>2</sup> for tapes on Mylar and 5N/mm<sup>2</sup> for tapes without Mylar. Taking temperatures should be max. up to 80 degr.C. Higher tacking forces and temperatures may reflect in stack distortions.

- Tape distortion properties

Some tapes with too much plasticizer tents to distort, when pressure and temperature is applied for taking. Distortions reflect in bad alignment and undefined stack shape. Stretching such piece of tape its elongation is high. (Like pulling rubber sheet) Tape stretching elongation should be as small as possible. In any case should be bellow 2%, before tape brakes. Tape distortions properties are mainly critical using organic binders. Water based tapes have better distortion properties.

- Tape softness

This characteristic is somehow in coincidence with distortion property. Tape must have some softness in order to accept thickness deviation in the tape. If one part of tape is thicker for 1micron, it will bring 100 micron thickness at final 100 layer stack. Such not uniform tape thickness should be compensated by local tape deformation during staking.



Most of green tapes based on organic binders have these properties. Sometimes very “rough” water based tapes, without suitable additives, are problematic. During stacking, surface of stack must be flat and smooth.

### Alignment accuracy influences observing alignment trough via holes

Observing alignment rough via holes following influences has to be taken to account:

- Punching accuracy

Punching accuracy depends of punching machine accuracy and sheet size. In most cases this accuracy is less than +/- 10 microns for 8x8 inch sheet size.

- Clear cut of hole edge

During the tool wear out, punching quality get worse. Not velar cut may influence to the vision alignment accuracy, if alignment is done on fiducial hole.

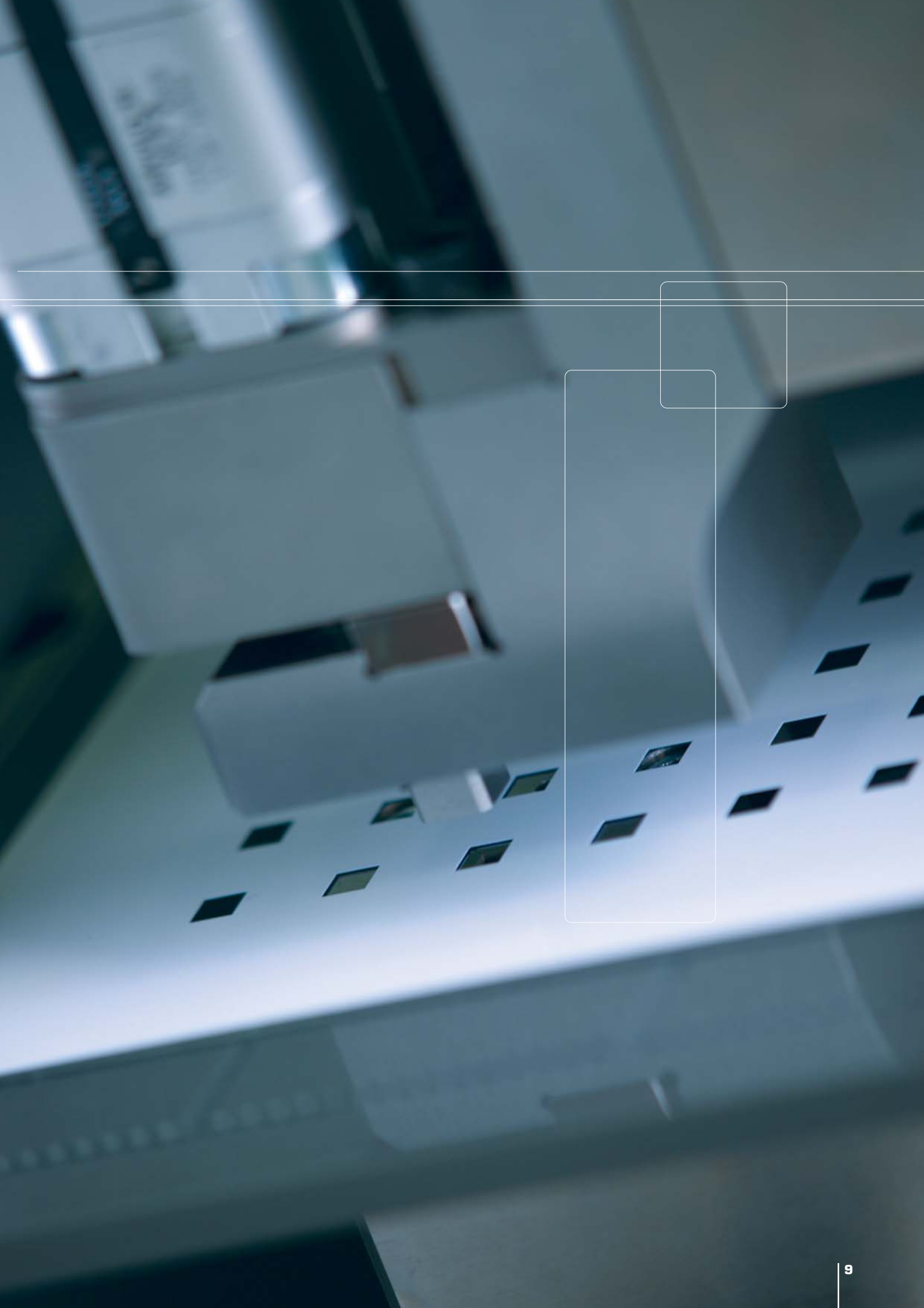
- Ceramic tape influence, as described above.

### Conclusion

Described are major influences to the stacking accuracy, not all. Stack generally shows how total production process is optimized. Expectations like, stacking machine will repair previous week points in production technology, are utopic. Final results are always combination of machine and materials. Some customers, especially those who do not control materials, or they do not want to exchange any material properties; can be at the end disappointed. For us, as machine producer is a general rule valid: If any part of stack is perfectly aligned, than the misalignment problem should be generally found somewhere else.

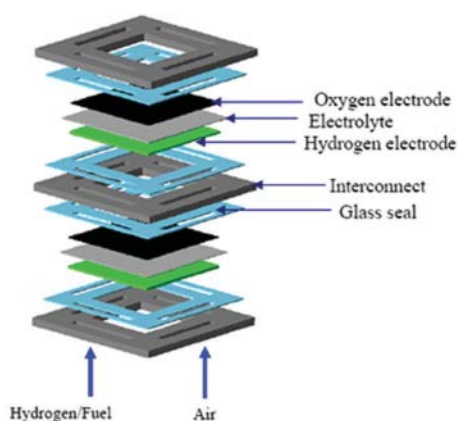
J. Štupar, Technical manager





# Solid oxide fuel cell technology and equipment development

The most promising fuel cell for the efficient use of natural fuel resources is the solid oxide fuel cell. New low temperature fuel cells exhibit more than 50% electric conversion efficiency. In combination with heat recovery more than 90% of energy efficiency can be reached. While the first systems now coming to the market for co-generation at home or in remote areas, development speed is increasing. Developments concentrate on lowering the temperature by use of new cathode materials and improvement of processing of the ceramic materials to allow volume production of fuel cell plates with higher efficiency.



The core of the SOFC is a ceramic multilayered plate consisting of an anode, an electrolyte and a cathode. Efficiency can be increased by the use of thinner electrolytes supported by a thicker anode. Keko Equipment in cooperation with Haiku Tech have now developed several material and equipment systems. Using our extensive experience in similar systems for micro-electronic components we can produce tapes with a thickness below 5 micrometer thickness. By using the lamination process we have been able to produce multilayered anode-electrolyte systems with electrolytes below 5 microns. The advantage of lamination of tapes is the guaranteed quality of the thin sheets with a process that allows for high volumes. The newly developed range of tape casters is now available for high volume production of sheets. The equipment now boasts laser thickness measurement and automatic doctor blade control. Fully automatic collection of tape as sheets ready in cassettes, is available for integration with automatic lamination equipment. By punching holes can be made in the green anode tapes to facilitate the fuel gas flow to the electrolyte.



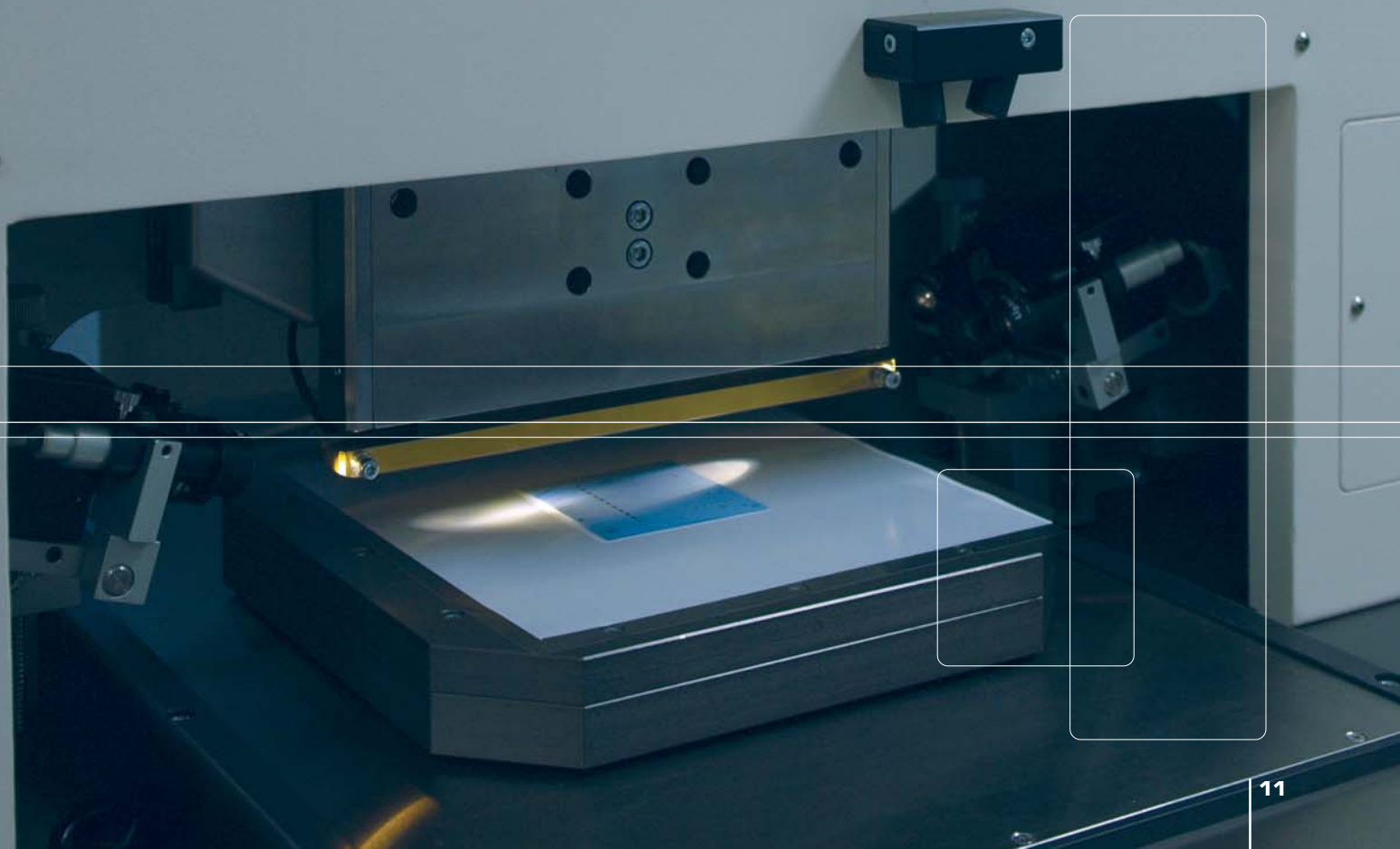
**Tape caster model CAM-H2510**

After tape lamination and firing, further layers can be applied by screen printing processes. For example the cathode layers can be applied fully automatically onto the fired half cells.

For laboratory use a P-200 printer can be used. For high volume production an automatic screen printer is used with 3s print to print cycle. As print lay down is high a IR drier is used for fast drying.



**Automatic screen printer FCP-21R**





# Hot melt screen printing technology for solar cells

Hot melt screen printing materials had been introduced to the solar cells producers couple of years ago. This new promisable technology could bring several advantages compare to conventional solar cells electrode screen printing. Unfortunately this technology never came to real mass solar cells production, as there where no production machines available on the market. Based on experimental tests we conclude, that existing hot melt screen printing process description can be only partly applicable. From that reason we developed new process suitable for mass production.

New process and machines will have following main advantages :

- machine output identical or higher compare to conventional screen printing
- automatic hot melt paste supply during the run
- no drier for paste drying required
- better print quality printing thick, fine line electrodes, compare to conventional screen printing technic
- identical or lower equipment costs compare to conventional machines
- smaller footprint of equipment



A production hot melt screen printing machine will be introduced to the market in May 2010.



# Laser micro holes drilling in green ceramic tape

Vias in green ceramic tape for LTCC, HTTC, MLCI and other components are still mainly made by mechanical punching.

Punching technology came to the limits regarding minimal hole diameter and speed. Minimal via diameter is mechanically limited by punching pin strength and is nowadays app. 50 micron. For mass production this size could be already problematic, as thin punching pin brakes easy.

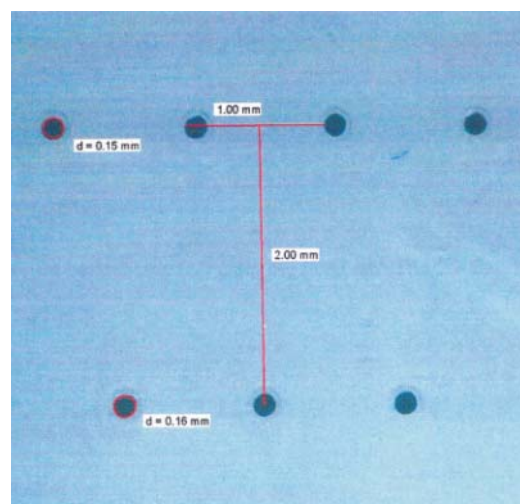
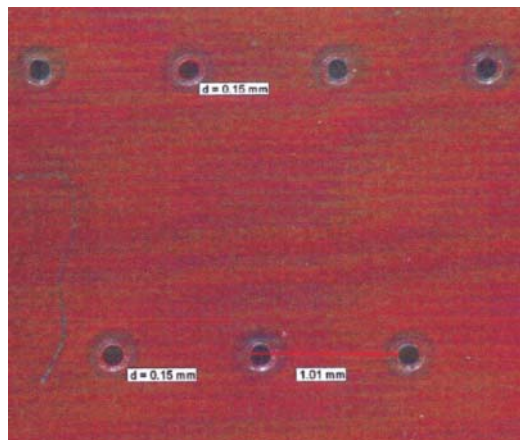
Using single pin tool maximal punching speed can be up to 20 holes/s (10 holes/s at 50 micron pin dia.) As component miniaturization requires vias down to 25 microns and high output, laser punching process is used.

Keko Equipment is following general market trend. In the past several years we did many tests on different green ceramic tapes using different laser sources. Based on these experiments we conclude following:

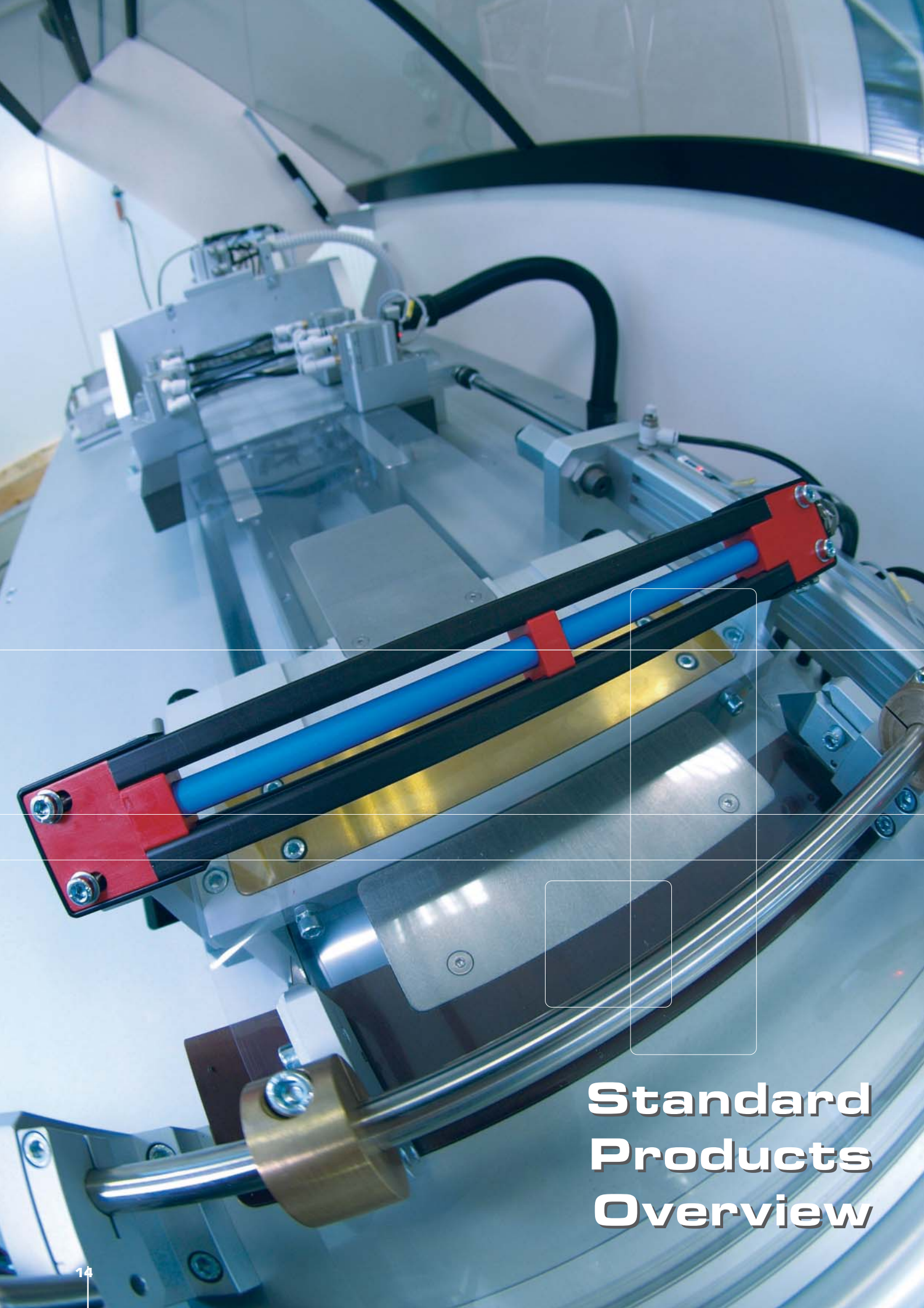
- compare to mechanical punching, laser punching process has much higher output
- minimal hole size depends of laser type and is around 30 microns
- punch quality and output depends of many parameters like, ceramic type and thickness, carrier film type and thickness, laser wave length, laser punching mode, laser stability and laser power
- thermal shocks on foil and glass forming around the holes can be sometimes difficult to avoid on particular foil, especially, if high punching speed is required.

We would offer laser punching machine to the market already, if we would not be disappointed with first test results. Nowadays using new laser technologies, we can optimize laser punching process for particular foil, getting good results on many foils.

Based on this knowledge, Keko Equipment can offer custom laser punching solutions, selecting proper laser and setting proper punching regime for particular requirements. Based on customer material test, we can offer custom laser punching solution with punching speed up to 1200 holes/s.







# Standard Products Overview

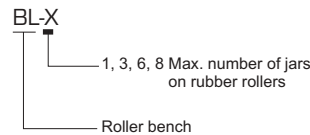


Slurry  
preparing

 Roller benches  
BL - series

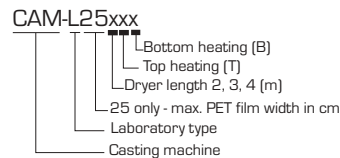
- adjustable rotation speed and time
- adjustable to different jar sizes

## Models:


 Tape  
casting

 Laboratory tape casters  
L-series

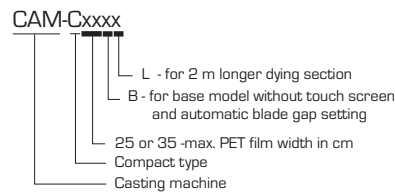
- for laboratory or small production volume
- casting on PET film
- casting speed control
- gravity slurry feeding
- tape winding



Tape casting on polyester film

 Compact tape casters  
C-series

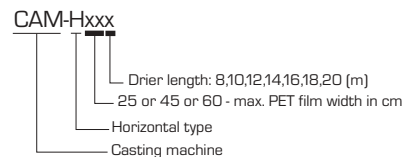
- compact size requiring minimum floor size
- suitable for solvent and water based systems
- high accuracy in thickness control
- automatic tracking of carrier film
- automatic slurry feeding
- applicable for up to 100 micron tape thickness



Tape casting on polyester film

 Horizontal drying zone  
tape casters  
H-series

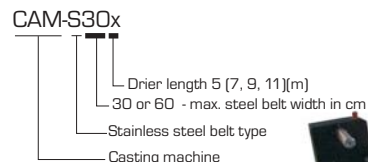
- thickness 5-500 microns (0.2 - 2 mils)
- advanced drying regimes possible
- high accuracy in thickness control
- automatic tracking of carrier film
- automatic slurry feeding



Tape casting on polyester film

 Steel belt tape casters  
S-series

- suitable for price sensitive applications
- different drying regimes
- high accuracy doctor blade
- automatic tracking of steel belt
- automatic slurry feeding
- tape winding

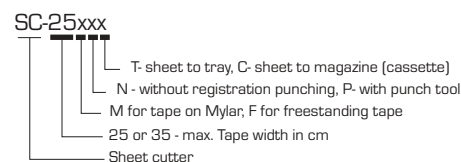


Tape casting on steel belt

 Tape  
blanking

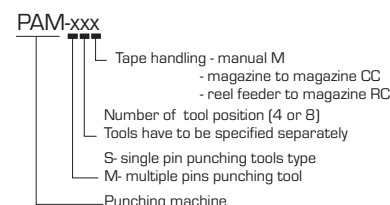
 Automatic green tape blanker  
SC-series

- blanks single sheets from a roll of green tape
- suitable for freestanding or Mylar based tapes
- trims sheet edges
- punch registration holes
- transfers blanked sheets to a magazine
- sorting blanked sheets according to their thickness


 Tape  
punching

 Punching machine  
PAM-series

- punch holes for vias and registration in green tape
- punch cavity rectangle or square holes
- Manual, CAD, NcDrill and DXF file input
- tool breakage detection
- automatic sheets re-alignment



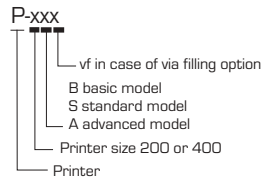
Especially suitable for LTCC production

## Screen printing

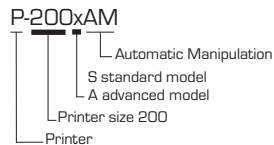
 Screen printers  
 P - series

- Three models available to meet all requirements
- Fully programmable printing parameters
- Print/print, print/flood, flood/print, on contact print, stencil printing, via filling
- Extensive options for demanding advanced technology applications

## Models:


 Automatic screen printers  
 P-series

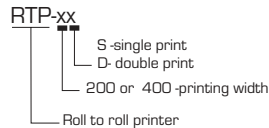
- Automatic sheet handling, printing, drying process
- Two models available to meet al requirements
- Fully programmable printing parameters
- Print/print, print/flood, flood/print, on contact print, stencil printing, via filling and screen cleaning
- Extensive options for demanding advanced technology applications



## Roll to roll printing

 Automatic roll to roll screen printers  
 RTP-series

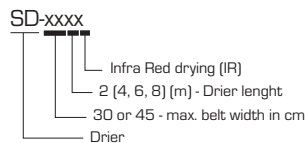
- Automatic screen printing on to tape from a roll suitable for different application
- Advanced print alignment feedback
- Double color printing with precise alignment version
- Specially designed for MLCC high layers production
- Efficient tape drying- enshure short cycle time
- Printed tape tracking control on winding side



## Drying

 Drier  
 SD-series

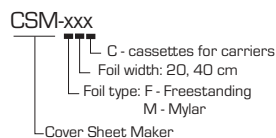
- dry single sheets, substrates or wafers after printing
- air flow ensure high drying efficiency
- adjustable internal and fresh airflow circulation.
- sheets are transported by teflonized mesh belt
- IR fast drying version available
- height adapted to Keko manual screen printers



## Cover sheets making

 Cover sheets maker  
 CSM-series

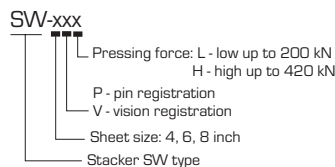
- Makes cover sheets directly onto carrying palette from a roll of tape
- Glues the cover sheet to custom carrying palette
- Sheet blanker and press in one unit



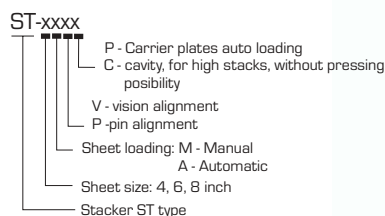
## Stacking

 Stacking machine  
 SW-series

- Universal manual stacking machine for low to medium LTCC or other similar component production
- Suitable for tapes with or without carrier film
- Process on one carrier palette
- Possible to start building stack from top or from bottom


 Stacking machine  
 ST-series

- Automatic sheet loading from cassettes
- Carrier palette automatic loading / unloading
- Automatically removes carrier film first, than stacks
- Pre-registration is done by registration pins
- Automatic vision alignment
- Suitable also for very high layer count
- Not suitable for tapes with punched holes



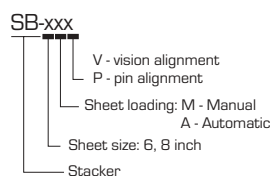
Process on one carrier palette at the same time

## Stacking

### Stacking machine SB - series

- Automatic sheet loading from cassettes
- Carrier palettes automatic loading / unloading
- Pressing first than removing carrier film
- Pre-registration is done by registration pins
- Automatic vision alignment
- Suitable for high volume production
- Suitable for various components

### Models:



Standard 24 carrier block carousel transport

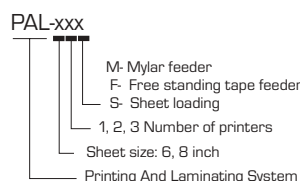


## Printing & stacking

### Print on stack technology

### Printing and stacking machine PAL - series

- Universal system for components up to 100layers
- High productivity = low cost per component
- Suitable for smallest components size
- Uses carrier film tapes, freestanding tapes and individual sheets
- Special configurations like:
  - several printers
  - several driers
  - sheet vision alignment
  - other special requirements



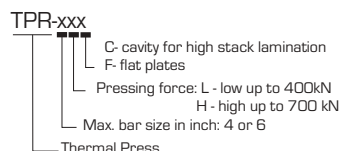
Contact supplier for particular application



## Laminating

### Uniaxial thermal press TPR - series

- Multiple stacks are laminated simultaneously
- High stack lamination possibility
- Simplified versions available
- Easy to operate, quick product turn-around time
- Rigid, compact design takes little floor space

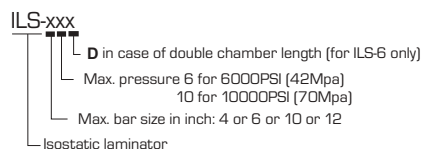


Higher forces in vacuum chamber on request



### Isostatic lamination press ILS - series

- Up to 40 stacks/substrates laminated simultaneously
- Wide selection range of bar size
- Easy to operate, quick product turn-around time
- Rigid, compact design takes little floor space
- Stores up to 99 pressure programs



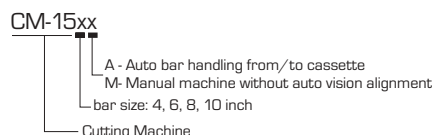
Vacuum sealing device included



## Cutting

### Cutting machine CM-series

- Cuts the most difficult high thickness green Ceramic Ware
- Automatically positions knife with high accuracy
- Automatically finds cutting markers
- Adjustable speed and cutting depth
- High productivity due to high cutting speed



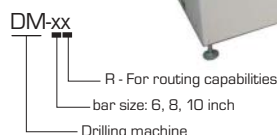
Pre and post heating plates optionally



## CNC drilling

### CNC Drilling machine DM-series

- Cuts round components out of green ceramic
- Drills holes
- Automatically positions bar by vision system
- Two working spindles with programable cutting speed alone using two different cutting tools
- DXF file conversion
- Vacuum bar fixing



## Solar and SOFC cells printer

### Automatic solar cells printing line SOC-series

- Automatically prints electrodes on to solar silicon wafers or thin ceramic SOFC substrates
- Loads wafers from cassettes or inline integration
- Unique, high speed self cleaning wafer/substrate transport ensures minimal manipulation and low breakage
- Short exchange time for different dimensions
- Vision alignment and breakage check
- High precision screen printing with precise squeegee control prints the electrodes
- IR drier for efficient drying
- Modular design, for different configurations
- Automatic unloading in to cassettes or on to furnace belt



Hot melt version available in year 2010

Contact producer for detailed specification!



## Trade Fairs & Exhibitions

We were attending CARTS Albuquerque 2007, CARTS Newport Beach CA 2008, EMPC Rimini 2009, IMAPS San Jose CA, 2007, IMAPS Providence RI 2008, IMAPS München 2009, SOFC Luzern, NEPCON Tokyo, Productronica...



# Installed Keko Equipment machines worldwide





# Company Profile

**KEKO Equipment Ltd.** is a leader in the manufacture of machines for the production of multilayer passive ceramic components but also many other products, based on a tape casting process.

Twenty-five years of experience have given us the vast knowledge that is now marketed under our own brand in the European, Asian, American and Australian markets.

Our roots stretch a long way back to when we were a unit of the Iskra consortium. Since 1995 the company is in private hands and its philosophy today is formulated by a team of highly motivated engineers and designers.

In addition to the extensive range of proven products, we focus our specialized know-how into custom manufacturing.

In the development of specialized technological solutions we take into account our customers requirements and the needs of each individual buyer, thus providing the basis for a successful long-term relationship.

This is aided by our widespread sales network that spans all continents, where we always cooperate closely with knowledgeable local agents. They have helped us to provide very successful post-sales services and ensure customer satisfaction.

Knowledge, flexibility and innovation are our company's key competitive advantages and our brand name's good reputation now reaches all over the world.



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