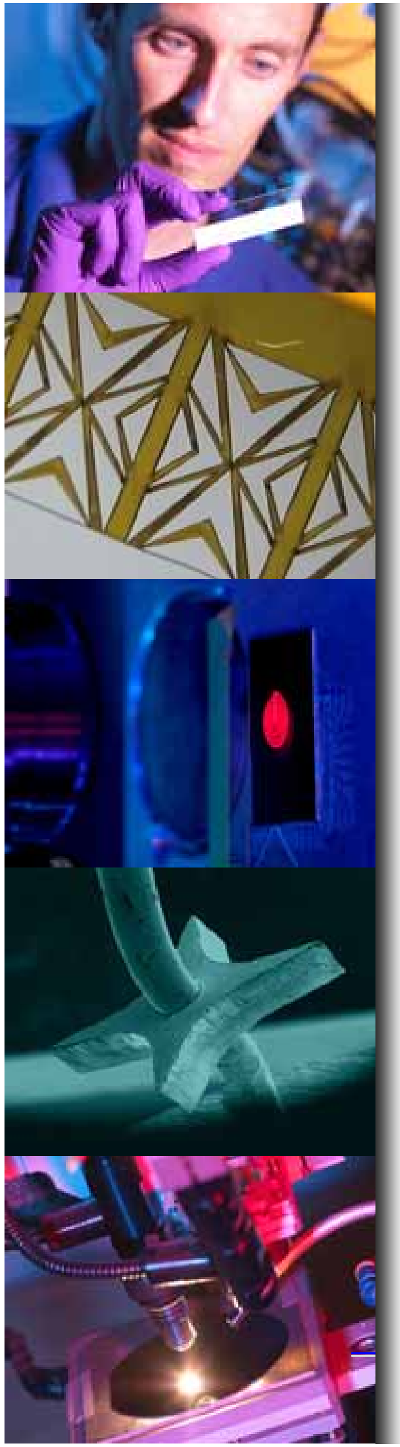


LASER MICROFABRICATION OF MULTIFUNCTIONAL DEVICES

Andy Goater, Gary Owen, Julian Burt & Nadeem Rizvi

UK Laser Micromachining Centre

"Laser Microprocessing of Challenging Materials and Architectures"
AILU Technology Workshop, Cardiff University, 4 July 2007

BIOTECH CHIPS

Complex multifunctional devices used in:

- Cell manipulation & detection
- Drug discovery
- Chromatography
- Virus detection
- Microarray technology
- Proteomics
- Genomics
- Blood analysis
- Microbiology
- Many aspects of personal healthcare

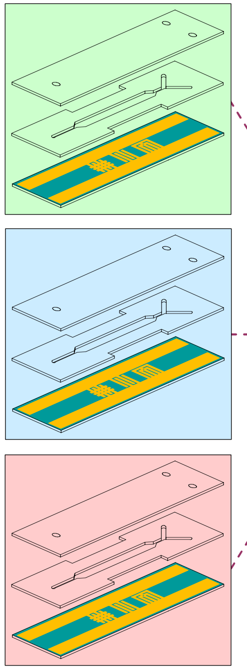
Development phase requires evaluation of numerous designs and concepts ⟶ ***LASERS***

Medical devices ⟶ Stringent validation and regulatory qualifications (high costs to market)

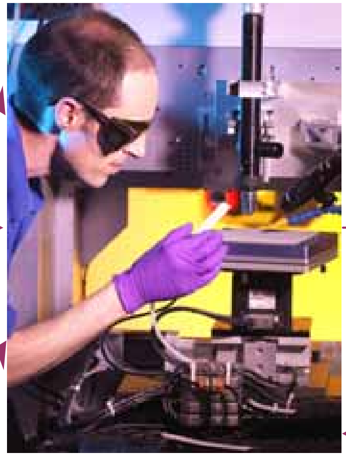
Mature products ⟶ Ultrahigh volume production

DEVELOPMENT CYCLE

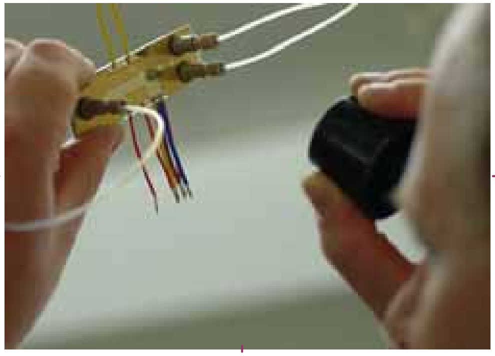
Designs



Process Development



Manufacture & Assembly



Testing

Batch Production

Laser microfabrication allows rapid implementation of design concepts

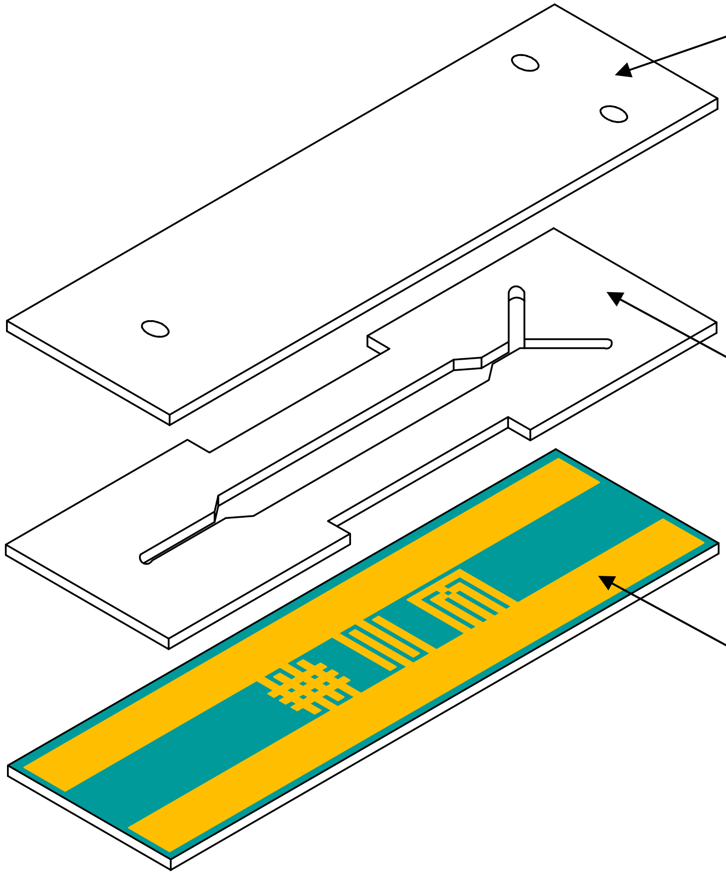
PROTOTYPE CHIP - DESIGN

Typical chip contains:

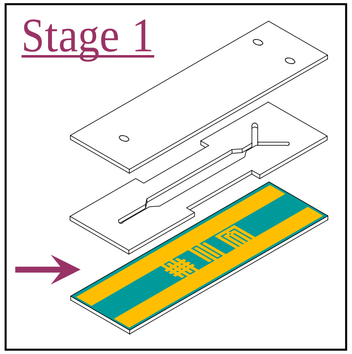
- Micro-electrodes
- Micro-channels
- Micro-holes
- Micro-optics

Common Materials:

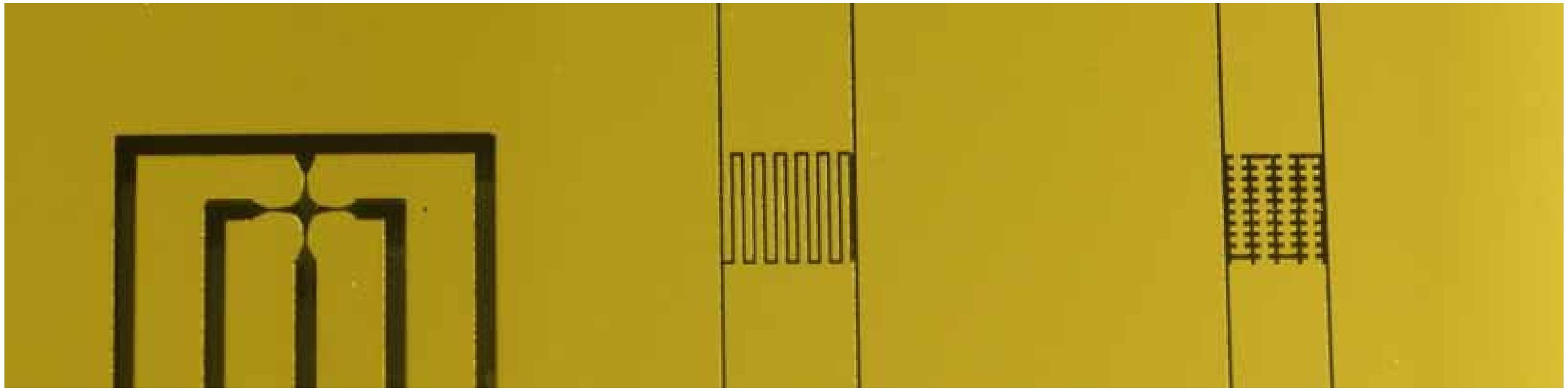
- Polymers
- Thin metal film
- Glass
- Composites



ELECTRODE LAYER

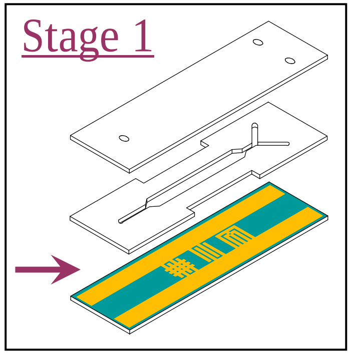


- 100nm gold on PC (glass is also commonly used)
- Various electrode designs for different functions
- UV laser patterning used to remove gold from substrate
- Different mask projection methods used depending on designs
- All masks made using laser cutting of polymers/metals



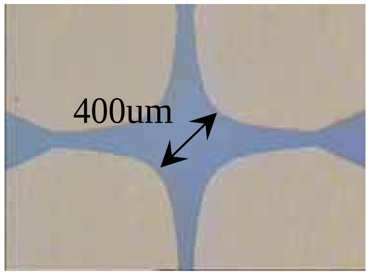
Polynomial electrodes *Levitation electrodes* *Castellated electrodes*

PATTERNING OF ELECTRODES (1)



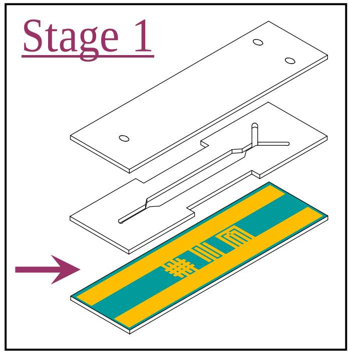
Details:

- Multiple masks used
- Mask dragging & synchronised mask scanning used



Polynomial Electrodes

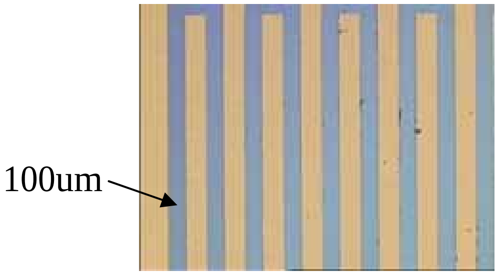
PATTERNING OF ELECTRODES (2)



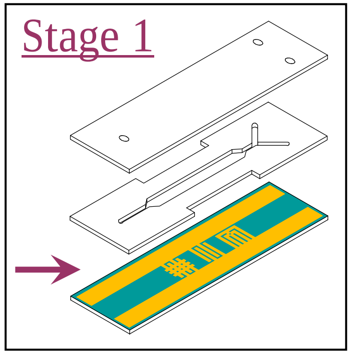
Levitation Electrodes

Details:

- Single mask used
- Mask dragging method produces sets of finger electrodes



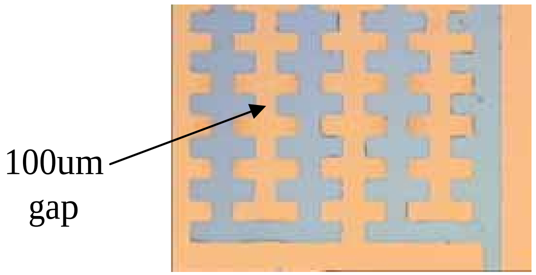
PATTERNING OF ELECTRODES (3)



Castellated Electrodes

Details:

- Multiple masks used
- Step-and-Repeat method used to cover large area with repeating pattern



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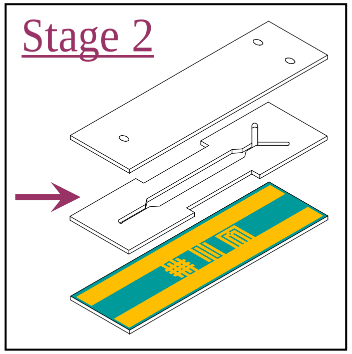
CHANNEL LAYER

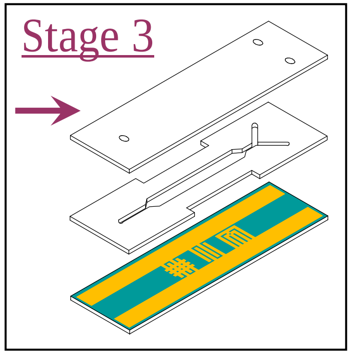


- 250um thick polyester with adhesive on each side
- Different thickness can be used
- Typical channel widths range from 100um – 1mm
- Channel cut in polymer using direct writing

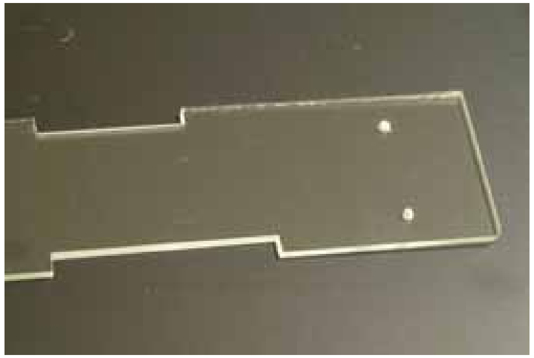
Channel layer after laser cutting

Example of high quality cutting of polyimide

ENCAPSULATION LAYER



- 1mm thick glass slide with through holes
- Different thicknesses can be used (down to ~50-100um)
- Typical holes size ~1mm (100um to 2mm holes also used)
- Holes cut in glass using direct writing
- Edges of glass also profiled to allow for electrical connections



Glass slide after laser drilling and profiling

Example of high quality drilling of glass slide

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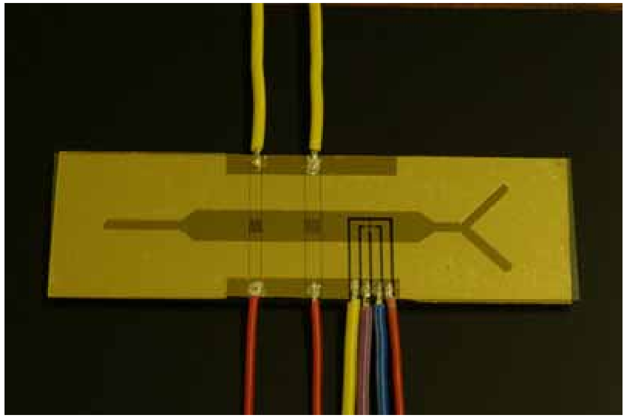
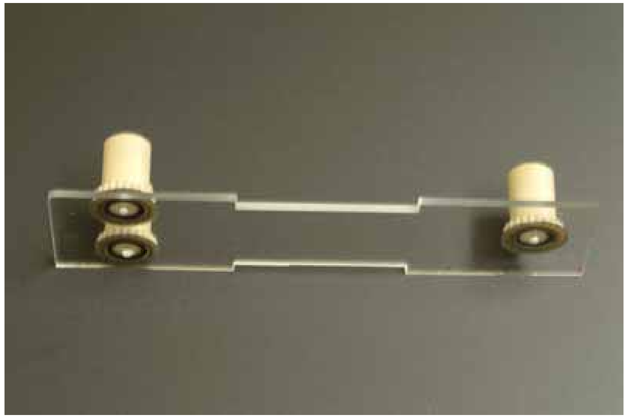
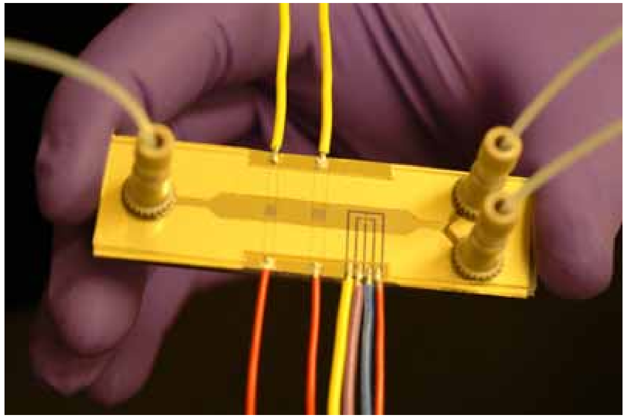
ASSEMBLY OF CHIP





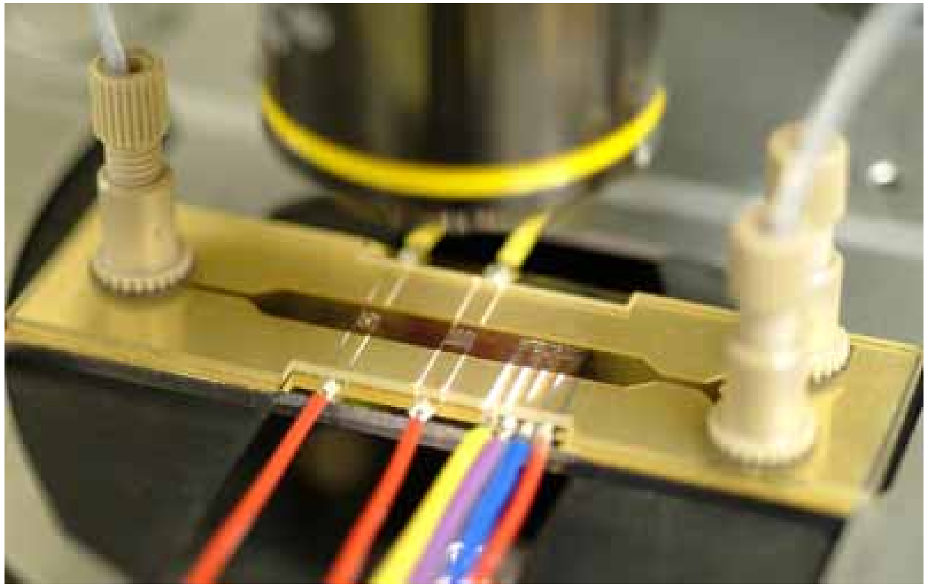


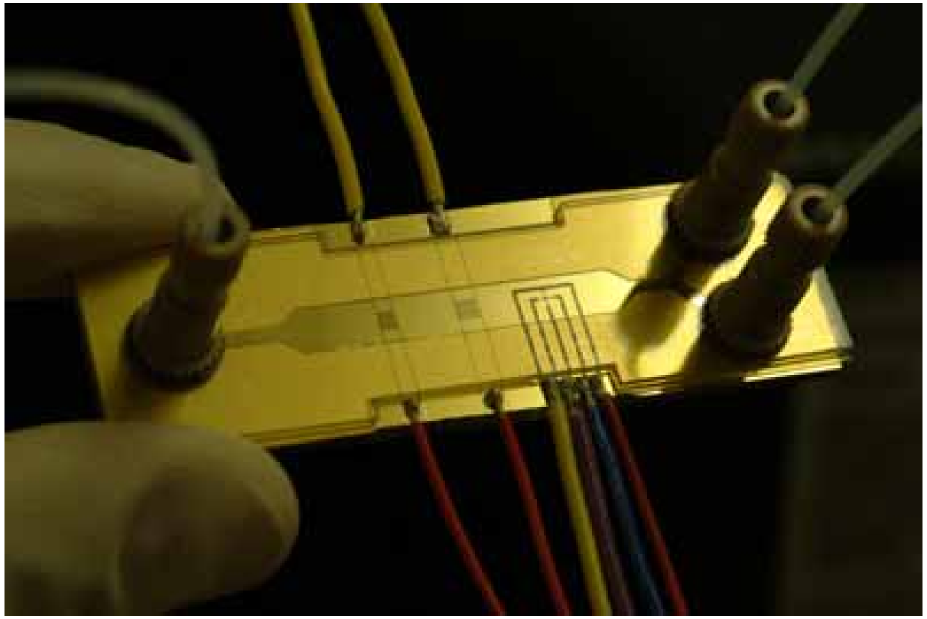
- Electrical connections are made with electrodes.
- Continuity and shorting tests are conducted.
- Channel layer is aligned and bonded to electrode layer.

- Encapsulation layer is cleaned and port assemblies are prepared.
- Port assemblies are bonded over holes in glass.

- Encapsulation layer and channel layers are aligned and bonded together.
- Complete chip is tested for leaks and flow.

COMPLETED DEVICE

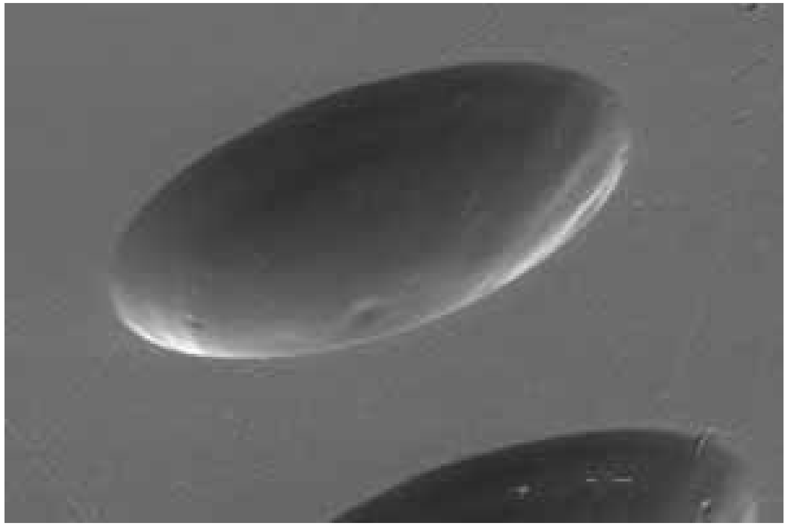




Assembled prototype device
during final testing phase.

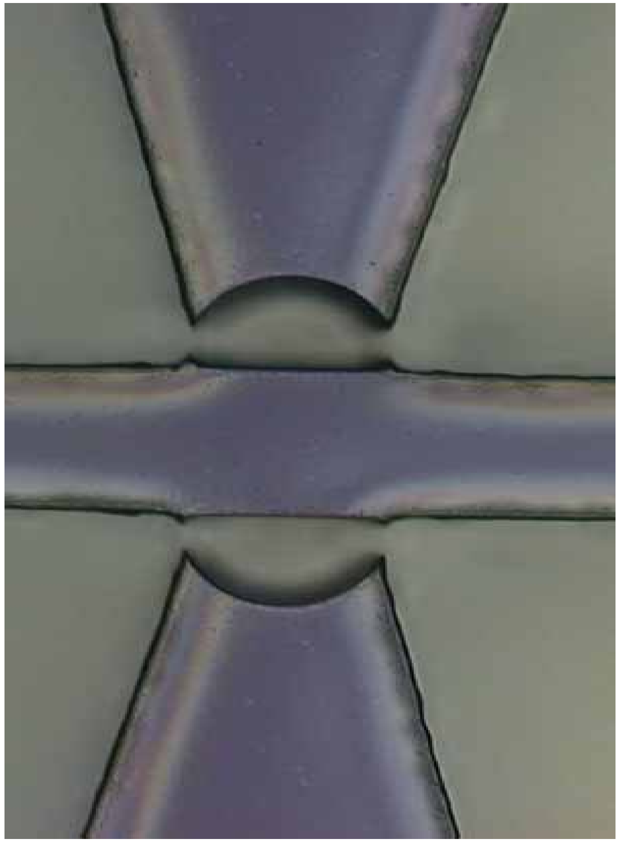
OPTICAL STRUCTURES

Devices can also incorporate optical elements (e.g. microlenses, waveguides) for interrogation of chip performance and enhanced functionality.



50um diameter microlenses in polycarbonate made with UV excimer laser.

Courtesy D.Morris & J.Burt, UWB (Optical Biochip project).



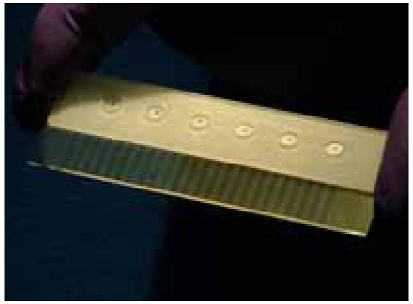
100um wide waveguide with lenses on each side, machined in polymer layer.

PROTOTYPE TO PRODUCTION

All elements of prototype chip can be automated for high volume production

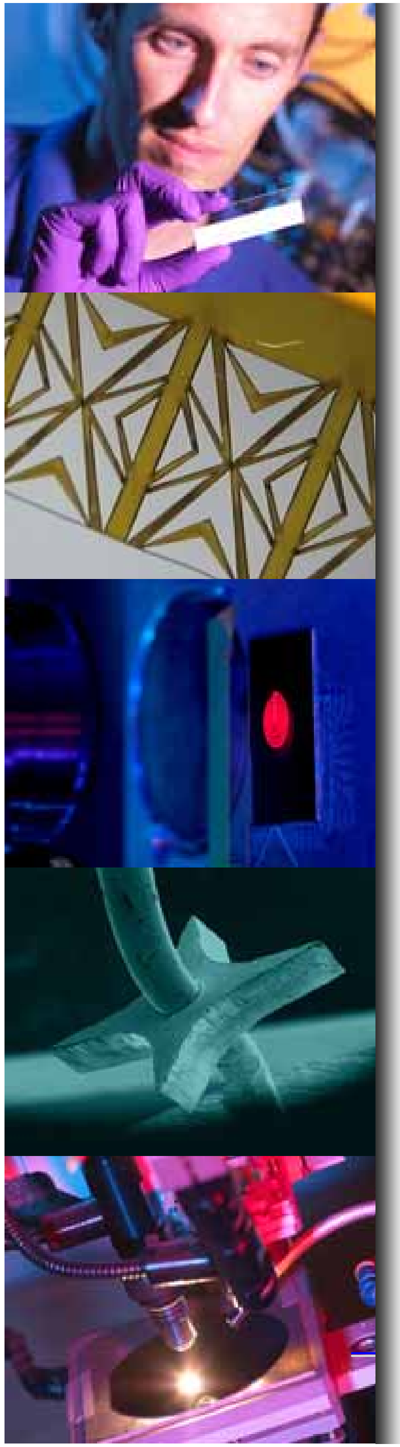
- Gold coating of substrates
  Batch process, can be made on wafer scale.
- Patterning of electrodes
  High-speed laser patterning (or photolithography).
- Channel layer
  High-speed cutting of polymers (reel-to-reel system).
- Encapsulation layer
  Cutting and drilling using high power (speed) lasers.
- Alignment & bonding
  Automated pick and place equipment can assemble devices.
- Electrical connections
  Automated wire bonding.
- Inlet/Outlet ports
  Automated handling and alignment systems place and bond.
- Testing
  Fluidic and electrical tests can be conducted automatically.

SUMMARY



The prototyping of a multi-level device has demonstrated:

- Ability of lasers to machine variety of materials and structures with high precision and quality.
- Great advantages of lasers during prototyping phases to evaluate designs quickly and cost-effectively.
- Implementation of multiple micromachining strategies in a single device to produce different features.
- Scalability – the process development work carried out can be used for automated manufacturing (i.e. laser processing is not 'dead-end').



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