

# Recent Developments in Laser Microprocessing Technologies for Manufacturing Applications

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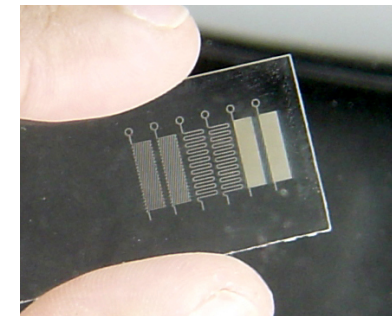
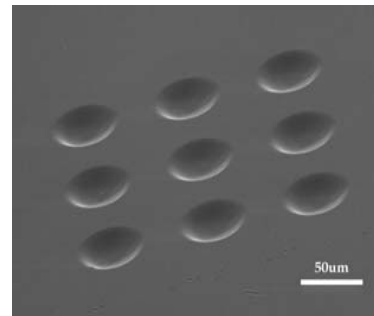
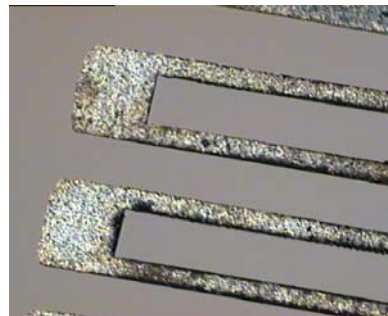
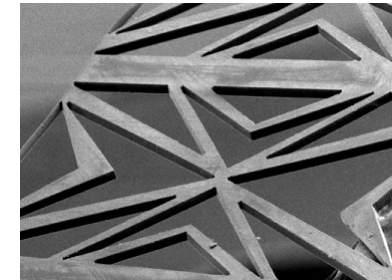
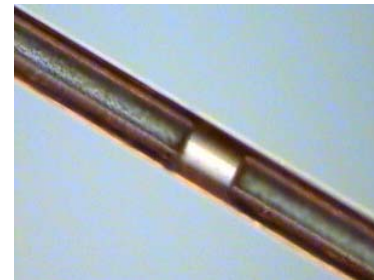
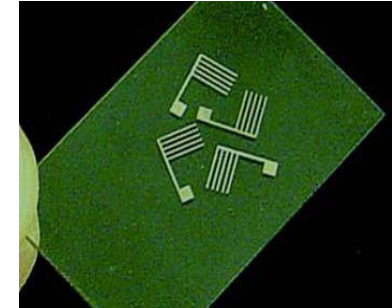


# UK LASER MICROMACHINING CENTRE

Established under DTI's Micro & Nano Technology Manufacturing Initiative in 2005.

Provider of commercial state-of-the-art laser micromachining services to industry and research.

- o Applications development work.
- o Feasibility studies.
- o Product prototyping.
- o Batch production.



UK LASER MICROMACHINING CENTRE

# LASERS IN MANUFACTURING

- Laser micromachining – a versatile, powerful & mature option for many manufacturing applications.
- Many sectors – e.g. displays, biotech, opto/micro-electronics – rely on laser processes for current and future production requirements.
- Key drivers for laser processing being adopted into manufacturing environments:
  - technical advantage
  - scalable processes
  - automation capabilities
  - economic drivers

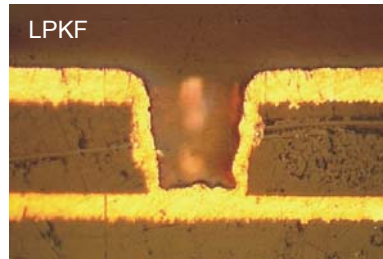
→ Unique blend of features.

→ Advantages over competing methods.



# MICROELECTRONICS & PCBs

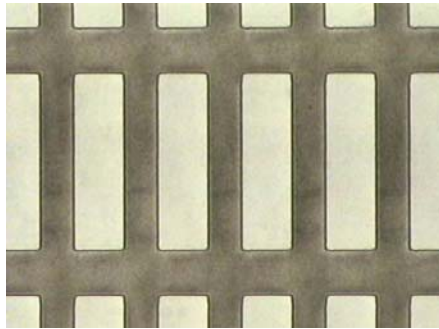
- o Ultra-high speed drilling of via holes.
- o Automated processing of wafers and boards.



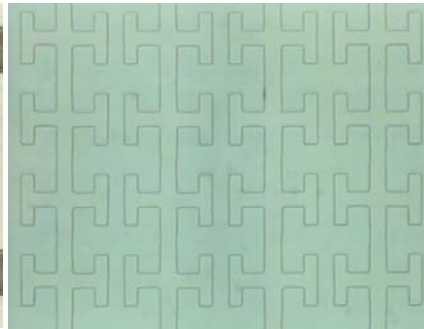
*Tool pictures courtesy of Exitech Limited.*

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# DISPLAYS & PHOTOVOLTAICS



Black matrix (LCDs)



Tin Oxide (FPDs)

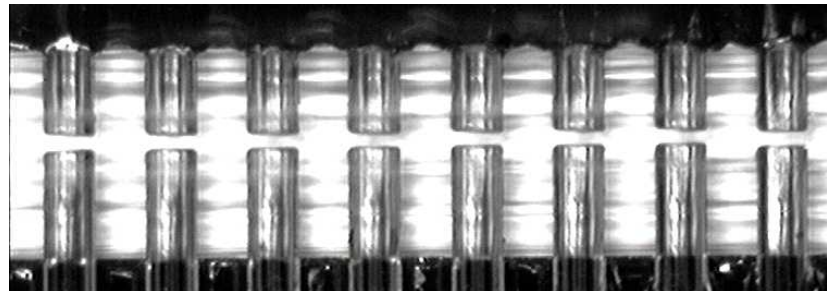
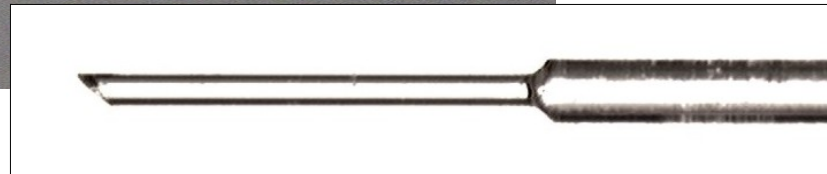
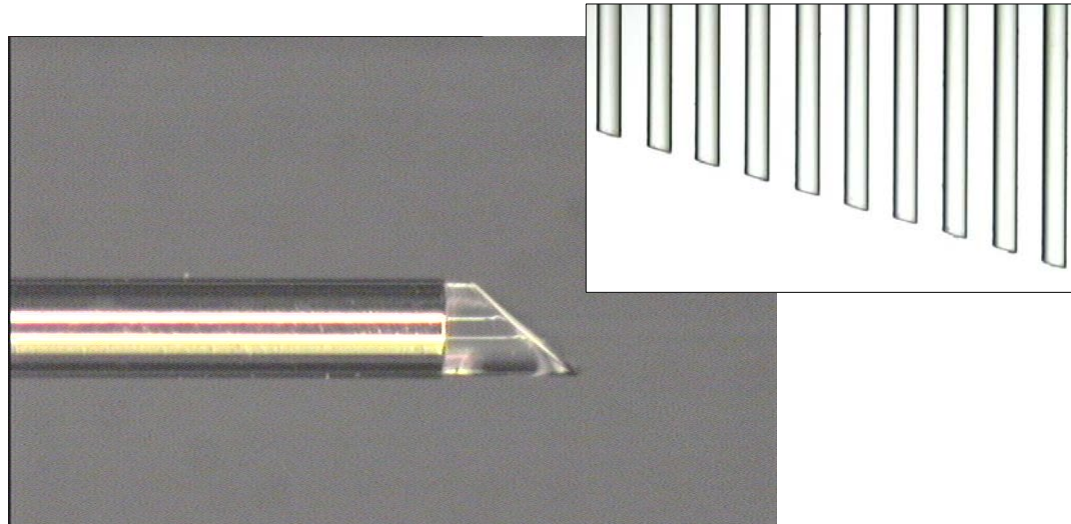


*All pictures courtesy of Exitech Limited.*

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# PHOTONICS & OPTOELECTRONICS

- Optical fibre devices.
- Stripping, cutting, shaping & cleaving.
- Automated or semi-automated processes.



*All pictures courtesy of Dr. Mike Osborne, Optek Systems*

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# MANUFACTURING OPTIONS

- Wide range of laser options: application-specific process development necessary.
- Manufacturing requirements include issues such as part handling, compatibility with non-laser steps and packaging.
- Experience gained in one industry can open up options for other manufacturing tasks.

Some potential high-volume manufacturing options for biotech products likely to benefit from developments made in photonics industries, e.g.

- 'pick and place' systems
- multi-axis alignment & handling
- ultra-high precision vision and metrology



# MICROTITRE PLATES

- o Microtitration ('microtitre') plates common in analytical biomedical and biochemical fields.
- o Multiple wells (6, 24, 96, 384, 6144) in each plate allow for parallel monitoring of different processes – automated handling and diagnosis of microtitre plates is routine.
- o New requirements in biological testing require electrokinetics – use of electrical fields to manipulate, characterise and analyse cells.

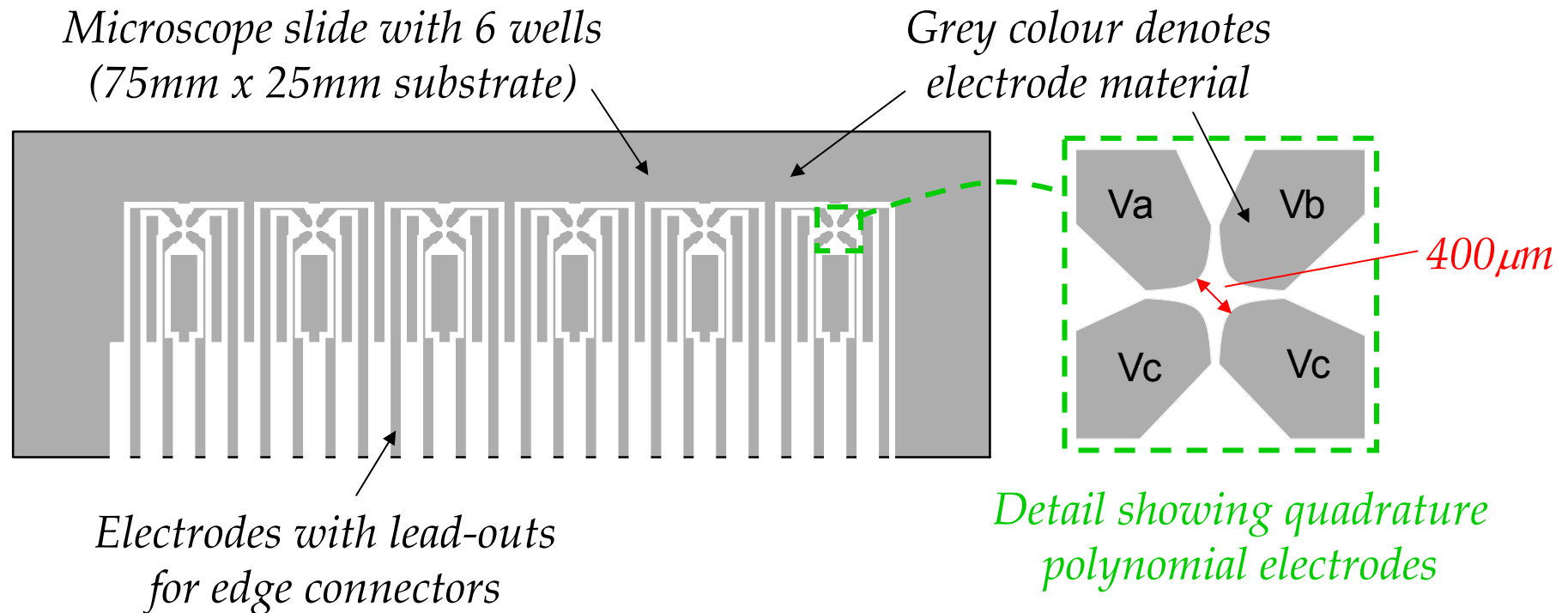


Require electrokinetic plates compatible with standard microtitre-type systems

→ new diagnostics, existing platforms.



# DESIGN OF ELECTROKINETIC MICROTITRE PLATES

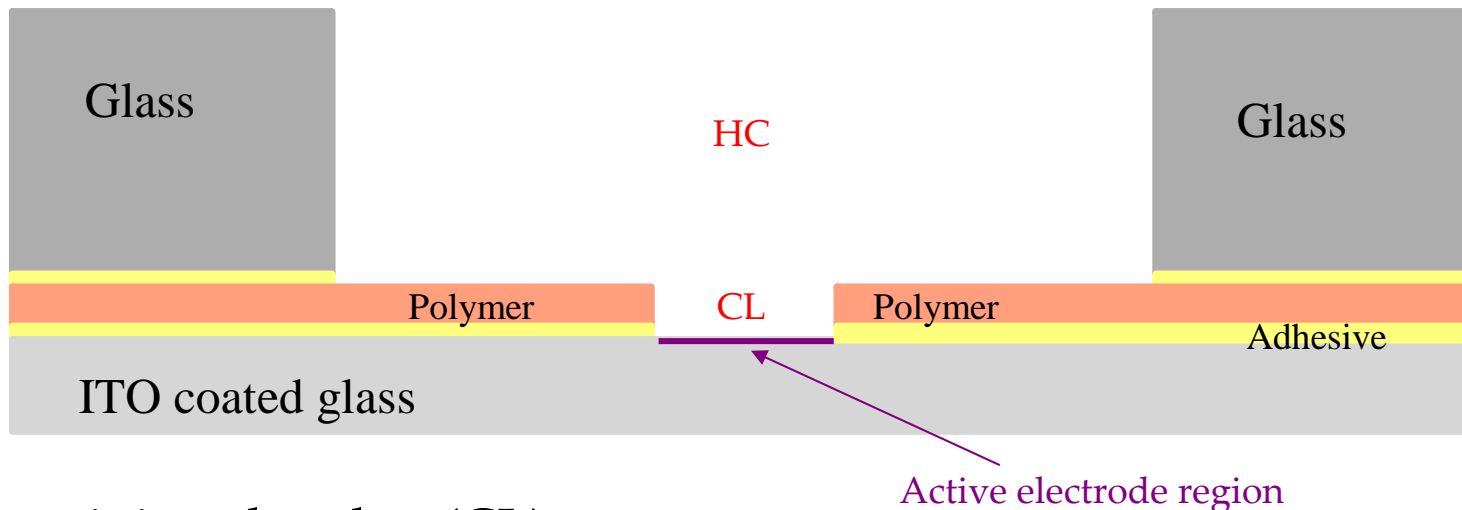


Electrodes energised with sinusoidal voltages to produce non-uniform or rotating AC fields.



# DESIGN OF ELECTROKINETIC MICROTITRE PLATE WELLS

Well is required over each active electrode region



Constraining chamber (CL)

Confines cells within effective volume of electric fields ( $\sim 40\text{nL}$ ).

Holding chamber (HC)

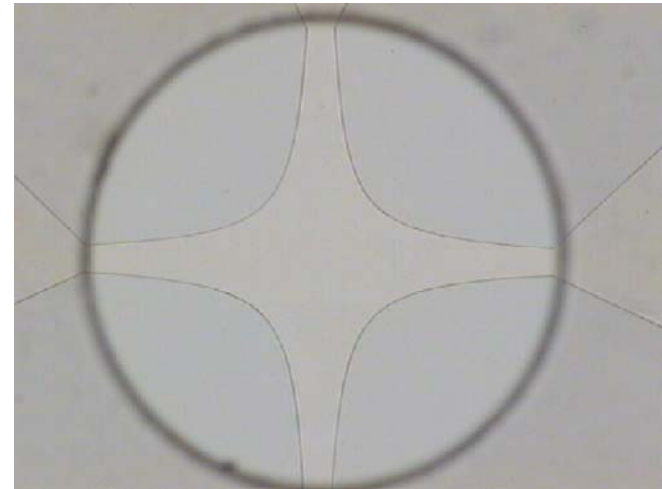
For dispensing of fluid containing cells ( $\sim 50\mu\text{L}$ ).



# FABRICATION OF ELECTRODES

- Glass substrate - biocompatible, strong, optically transparent.
- ITO electrodes – good conduction, allow optical imaging and lighting.
- Two stage patterning process using excimer laser.
  - Stage 1: active electrode region produced by mask scanning.
  - Stage 2: connecting electrodes produced by direct writing.
- ITO removal: 248nm, 1.5J/cm<sup>2</sup>, 5 shots.
- Active electrodes produced in ~10sec.

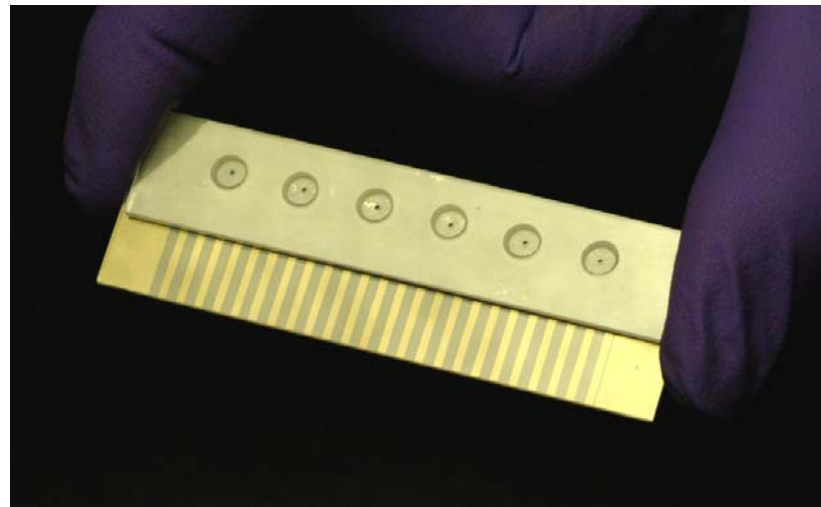
*Laser-machined ITO polynomial electrodes, also showing outline of containment chamber.*



# FABRICATION OF CHAMBERS

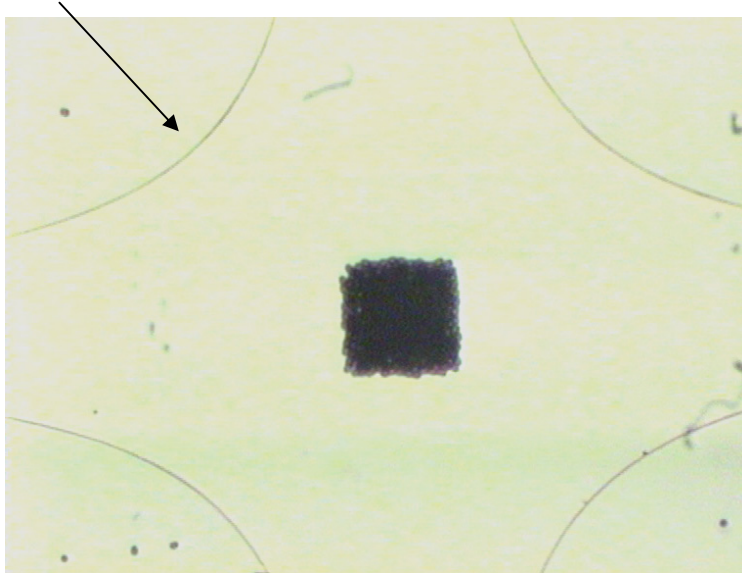
- Containment Chamber – polymer sheet with dual-adhesive layers.
- Holding Chamber – glass slide.
- Holes in chambers made using Ti:sapphire laser: 800nm, 5kHz, 120fs, 20 $\mu$ m spot size.
- Covering layers aligned over active electrode areas and pressure-bonded using adhesive.

ASSEMBLED PLATE  
*Laser-machined 6-well  
device showing electrodes  
for edge connectors at  
bottom and 6 wells at top.*

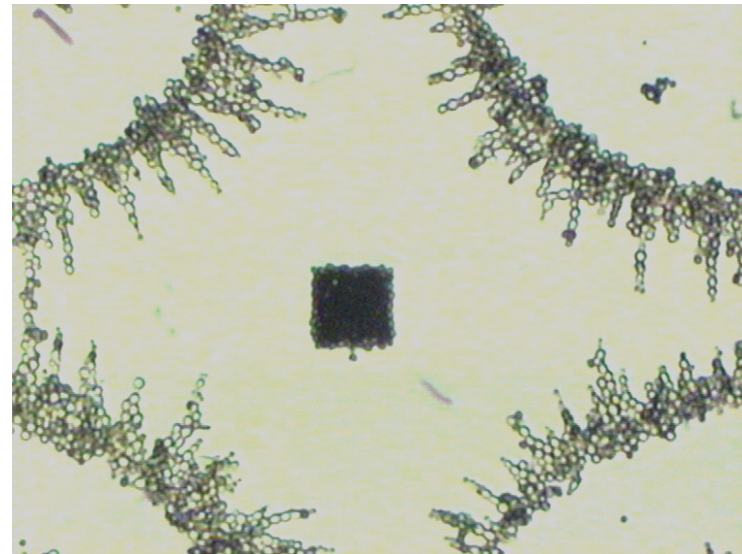


# OPERATION OF ELECTROKINETIC MICROTITRE PLATES

*Edge of polynomial electrode*



*The corraling of latex microbeads by  
negative dielectrophoresis.*



*Differential dielectrophoresis showing  
latex microbeads corralled by negative  
dielectrophoresis with simultaneous  
collection of yeast cells by positive  
dielectrophoresis.*



# HIGH VOLUME MANUFACTURING

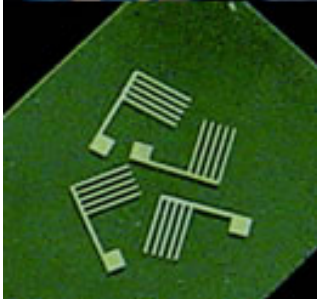
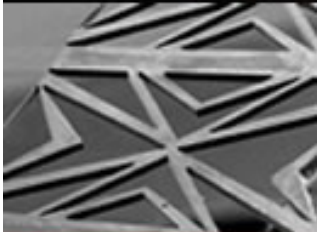
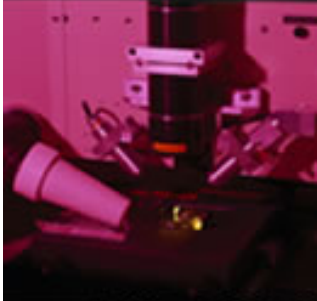
- o Electrokinetic multi-well microtitre plates can be made using laser micromachining methods and standard manufacturing equipment:
  - automated laser production equipment.
  - product-specific plate designs (different electrodes & wells).
  - automated handling of cover plates.
  - automated alignment, bonding and electrical testing.
- o High speed laser and handling production lines already in operation worldwide (e.g. ink-jet printers, product marking, CD production etc.).
- o No practical limitations to high volume production of plates.



# SUMMARY

- An electrokinetic microtitre multi-well plate has been produced using laser micromachining processes and tested.
- Production of such microtitre plates using high volume manufacturing methods will be typical for emerging applications, especially in biotech fields.
- Laser manufacturing continues to expand into new application areas.
- Mature processes already exist for high precision production and new ones are continually being developed.





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