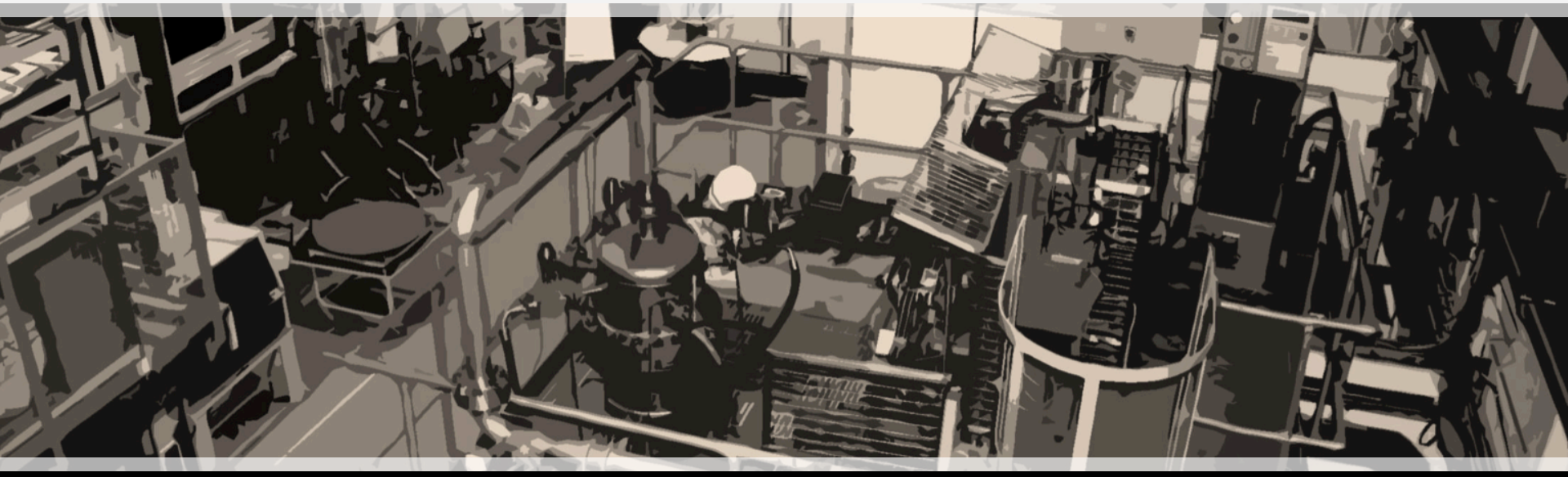
HVM Graphene+ 2014 Conference
Oxford, UK 15 May
www.hvm-uk.com

intrinsiq™ materials

Unconventional Solutions for Conventional Problems

Electronic inks and pastes for packaging, batteries, sensors, displays and touchscreens

Dr Paul Reip
Founder & Director, Government and Strategic Programmes



Intrinsiq Materials Background

- Founded as a QinetiQ corporate investment in January 2002 – **QinetiQ Nanomaterials Ltd**
- Spun out in 2007
- Locations:
  - Farnborough, UK (R&D, Production and BD Europe)
  - Rochester, NYS, USA (Development and Production)
- Team of 30 - 80% technical/scientific
- Technology Platform
  - Fabrication of Inorganic Nanoparticles
  - Current focus – conductive inks for PV
  - Also working thermoelectrics and nano phosphors

Nanomaterial Research Centre, UK


Now expanding in New York State.
Nanomaterial and ink production, US

IML Nanoparticle Production Facilities

Rapid Prototyping

- COMINA system for MNT Programme
- Low operating cost
- High throughput experiments
- Process flexibility
- Process control
- Fully instrumented
- Rapid data collection

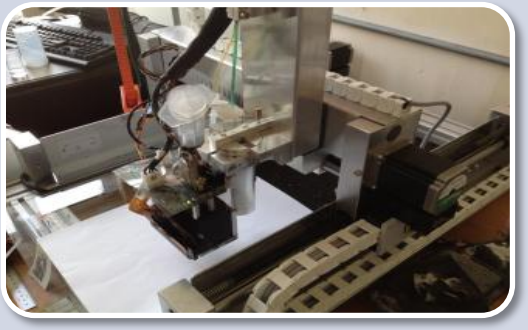
Pilot Plant

- Annual capacity pastes/inks: ~2500 Kg
- Built to withstand explosive and reactive materials
- Continuous process
- Inspected by HSE/DEFRA
- Fully approved by Zurich Insurance

Analysis

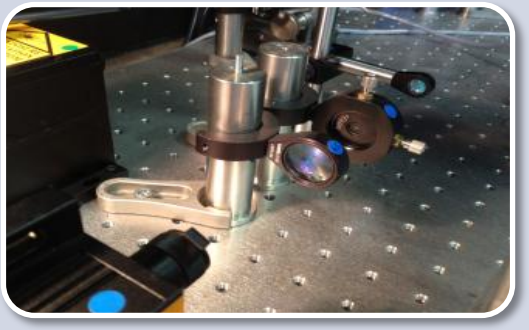
- Extensive Scientific Testing facilities
- SEM / STEM / EDX
- FTIR / ATR
- Particle Size Analysis
- DSC / TGA / BET
- Powder handling
- Dispersion capability

IM Development Laboratories



Print Laboratory

- Small scale inkjet system
- Small scale screen print
- Process flexibility
- Instrumented
- Rapid data collection



Sintering Capabilities

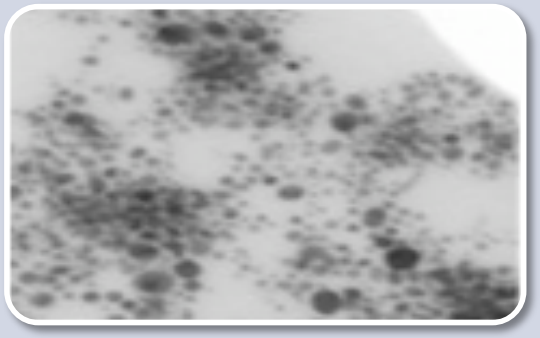
- UV system - Xenon
- Multi laser system
- Flexible
- Line widths to less than 3.9 micron

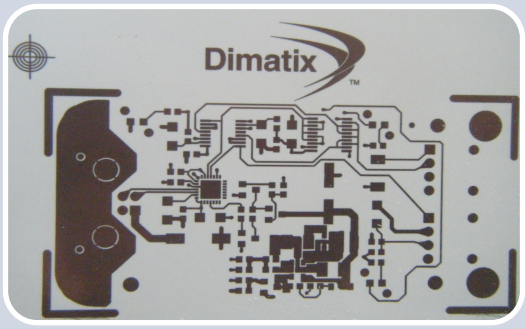
- ***LAPS-60***

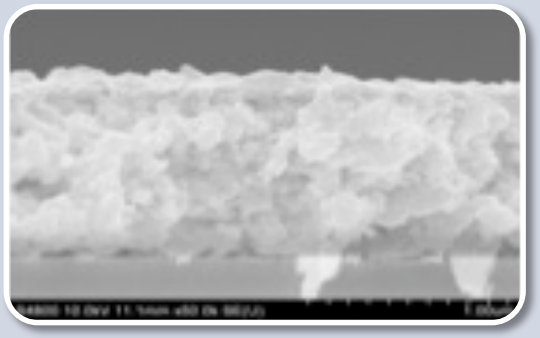
UV/VIS Laboratory

- UV / Vis Spectrometer
- Used for nano phosphor research

Copper ink – issues & solutions







Copper Reactivity

- Nano scale produced
- Coated with organic
- Gives 6 month life
- Functionalised surface

Print Technology

- Inkjet fully approved for Dimatix / Xaar
- Screen print inks available
- Polymers / ceramics / glass / FR4 etc etc
- Offset litho / flexo in development

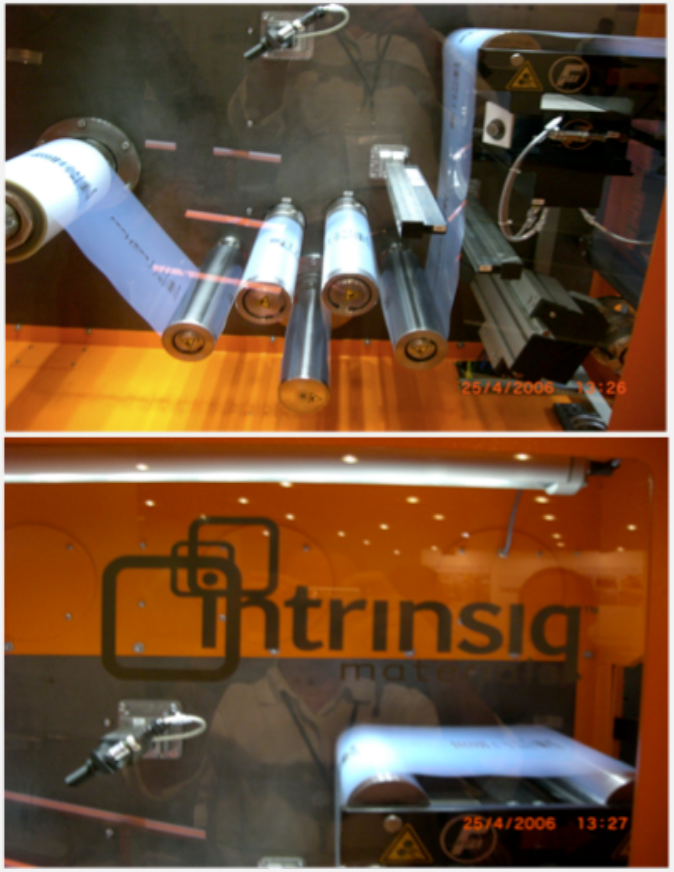
Sintering

- Broad Band Flash / Laser
- In milliseconds
- In air
- No substrate damage
- R2R applications in development

Examples – Broadband Flash Processing

- LOPE-C Conference Dusseldorf

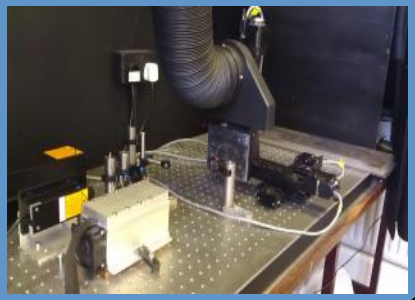
2 m/min – nano copper ink deposited by a new Fuji-Dimatix ink jet head, then dried & sintered using broadband flash

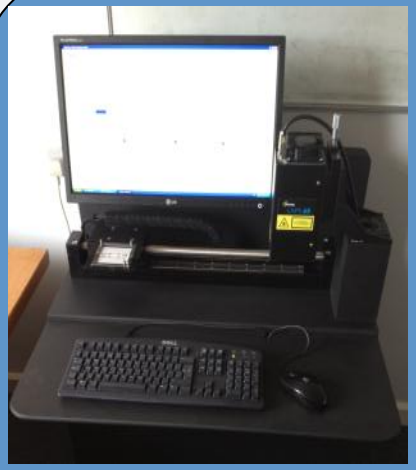


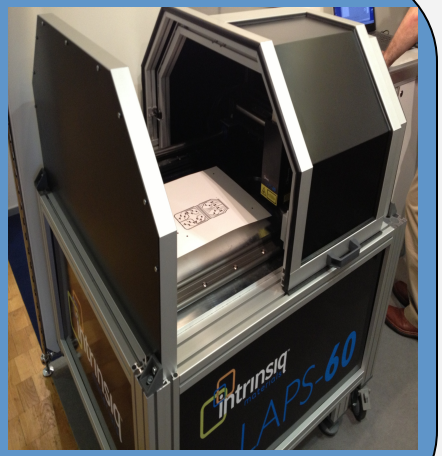
Laser Development

- Wide range of lasers and generic expertise available
- Developments underway
  - Commercial
  - Government sponsored
- IML developing a range of approaches in response to customer demand
- Lab system -> LAPS60 -> LAPS60 XY ->LAPS60 HSE
- New FASTLAPS programme will develop R2R system

Laboratory System

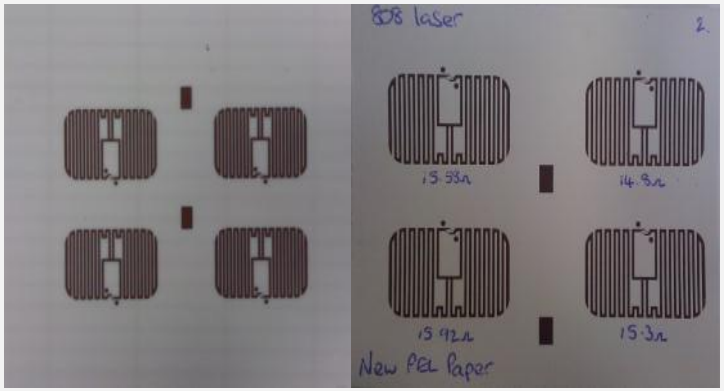




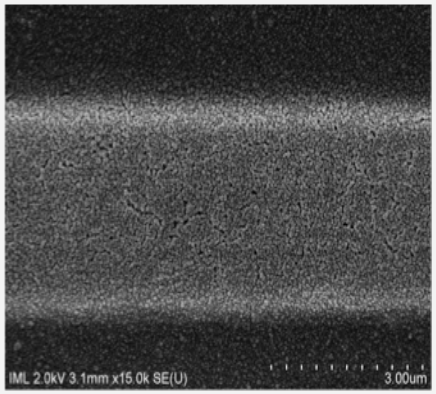


LAPS 60 System

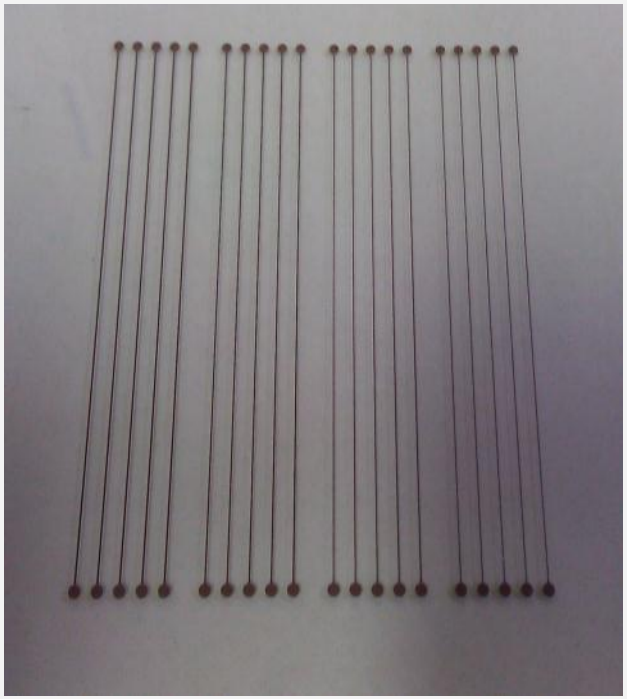
Examples – Laser Processing



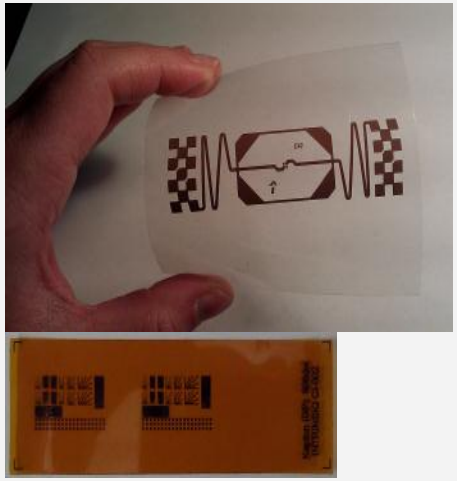
RFID on paper or PET / laser

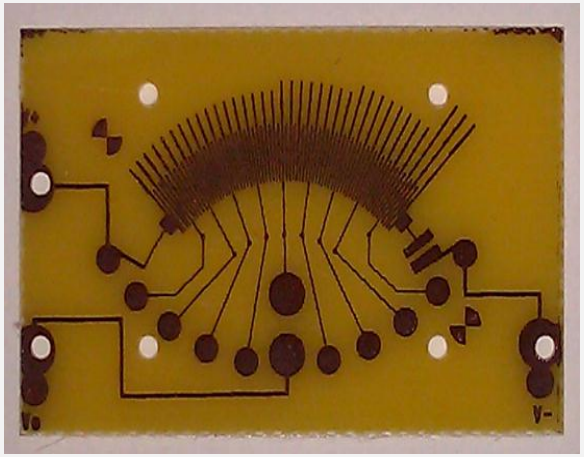


4µm lines / laser



Test lines 75µm, on PET / laser





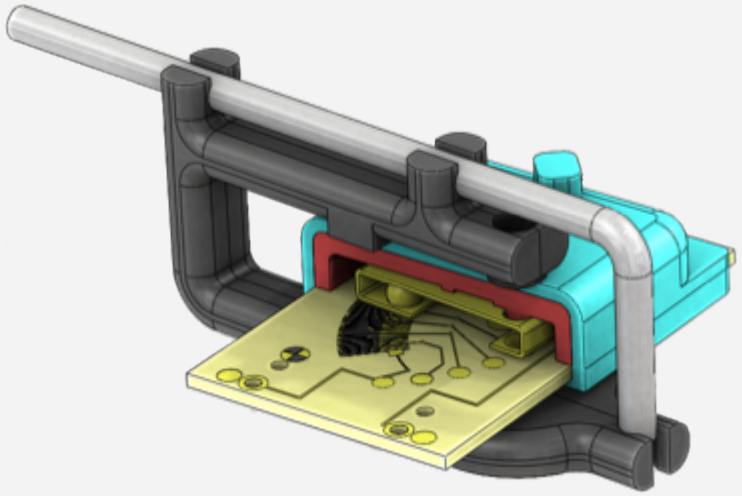
Examples of Intrinsiq copper inks applications

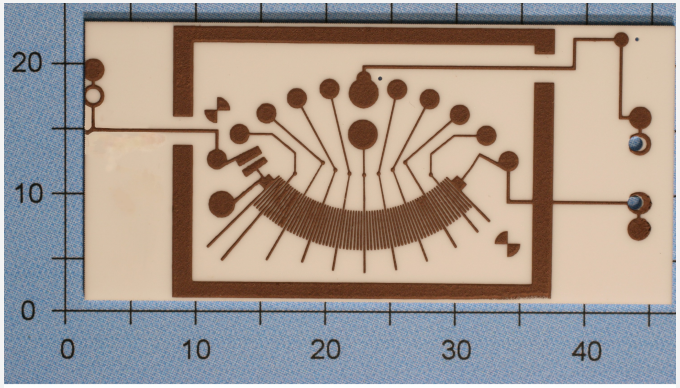
Application	Issue
Circuit development	Cheaper, finer lines, reduction in COG
Biosensors	Manufacturing route
High performance LED's	Manufacturing route
OLED lighting	Copper grids
Hybrid systems	Enhancement of conventional electronics

Circuit Development

Status:

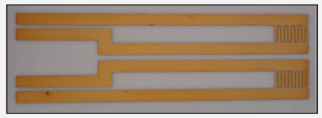
- Two different circuits being developed for consumer applications – contact sensors
- Initial Reliability Studies underway
- Programme has involved close collaboration with several key industry partners
- Lead company now willing to invest in process operations
- Development programme to extend technology to Non-Contact Sensors

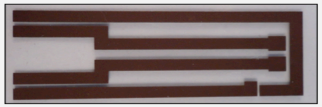


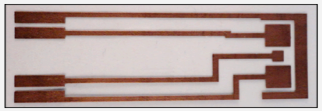


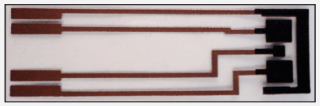
PROCID Programme

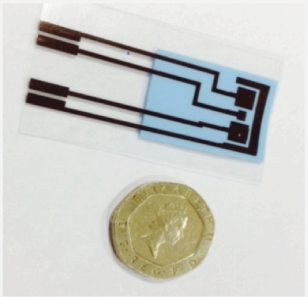
- Disease Detection system for STD's
- ***Antibody based impedance sensor***
- Exploitation requires cheaper faster electrode manufacture + optimisation
- IML nano copper – screen printed – laser sintered
- Trial on flexo and offset litho carried out – inks in development
- Joint programme with Intrinsiq Materials (Lead partner), Leeds University, The Needham Group, The Ryedale Group, Amies International, P1 Technologies





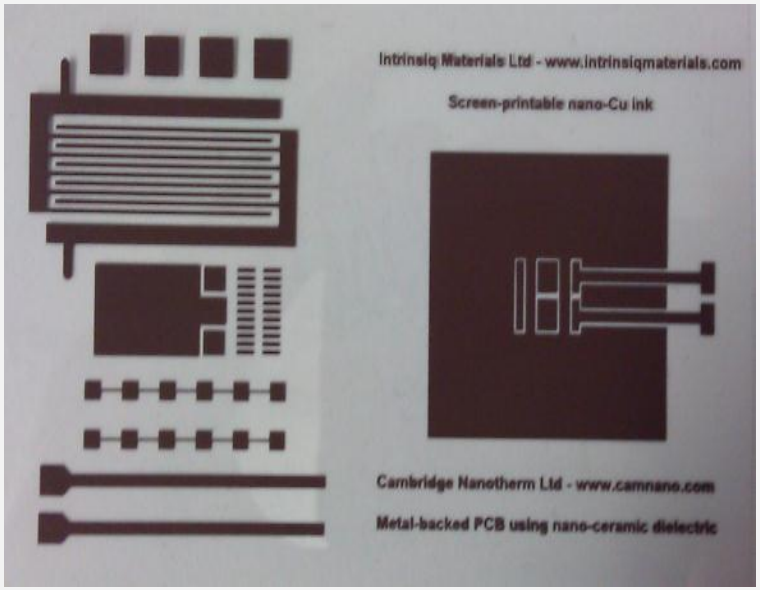






LED applications

- Require new packaging methods – existing PCB based approaches expensive –requires heat sink
- One approach – CEMLAD programme - Combination of IML ink and Cambridge Nanotherm high performance substrates for LED's
- Aim to reduce thermal issues for high performance high output LED's
- Print / sinter onto highly thermally conductive ceramic layer on aluminium substrate



OLED lighting

- Work carried out under LAPTRANS programme
- EU FP7 M-ERA.NET funded
- IML / PEL / Brunel University / PLANSEE / ORBOTECH
- Enhancement of ITO layer conductivity using printed / sintered copper grids

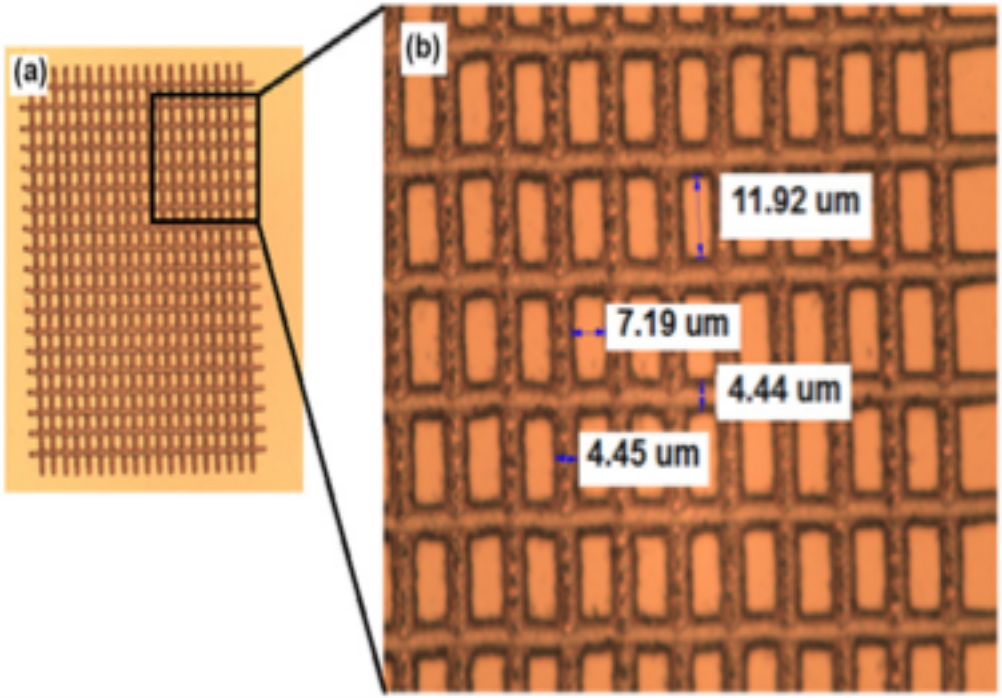
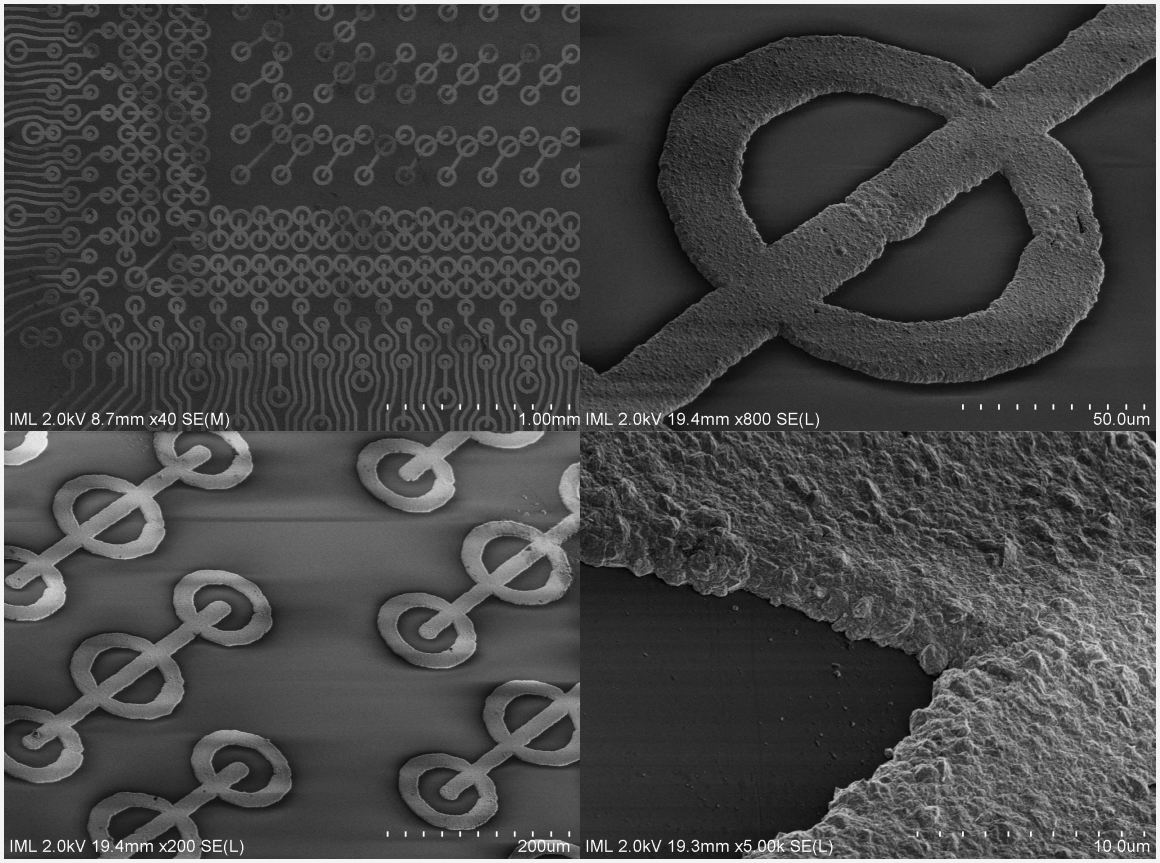


Figure 17. Fine metal grids generated by selective laser sintering of a copper NP ink layer (average pattern height $h = 450$ nm).

Laser sintering of copper nanoparticles
Michael Zenou, Oleg Ermak, Amir Saar and Zvi Kotler
J. Phys. D: Appl. Phys. 47 (2014) 025501 (11pp)doi:10.1088/0022-3727/47/2/025501

High definition printed electronics combined with conventional coating chemistry

- Direct Write approach



Design Courtesy of Atotech

Summary

- To increase speed of adoption high quality low cost conductive inks with cost effective sintering processes are needed
- Current sintering technologies achieve the required performance
  - High performance tracks manufactured
- Sintering tools are available in both oven / broad band flash
- Barrier to uptake is lack of cost effective sintering systems at the R&D stage
- IML has set out to support our customer base with a range of validated laser sintering tools
- These, and the inks to go with them, are now available ….

Thank you!

For more details please contact:

Dr Paul Reip
Director, Government and Strategic Programmes
paulreip@intrinsiqmaterials.com
mobile: +44 (0)7785 382 293