METHOD FOR MASK-LESS LASER-ASSISTED HYBRID ETCHING FOR INTERDIGITATED ELECTRODES IN SEMICONDUCTOR DEVICES AND DEVICE THEREOF

IITM Technology Available for Licensing

Problem Statement

- Various approaches, such as subtractive processes and additive processes, are used for the **fabrication of micro-channels or micro scribing on copper films**.
- However subtractive techniques such EDM and ECM have limitations in terms of minimum **achievable feature size and micro-tool fabrication** respectively.
- Additive techniques such as laser additive manufacturing and vapor deposition techniques **require masks and are prone to chamber contamination.**
- Photolithography and chemical etching techniques have limited scope due to use of **masks and toxic nature of etchants** respectively.
- there is need for a system and **method for mask-less etching which is reliable** and does not suffer from the problems discussed above.

Intellectual Property

- IITM IDF Ref.**2268**
- **IN 499893Patent Granted**

TRL (Technology Readiness Level)

TRL 4 Technology Validated in Lab

Technology Category/ Market

Category- Electronics and Circuits

Industry Classification:

- **NIC (2008)- 26101-** Manufacture of electronic capacitors, resistors, chokes, coils, transformers (electronic) and similar components
- **NAICS (2022)- 333242-** Thin layer deposition equipment, semiconductor, manufacturing
- **Applications:** Manufacture of semiconductors- organic field-effect transistors (OFETs), interdigitated back contact (IBC) solar cells and communication devices such as antennas, frequency selective surfaces etc

Market drivers:

The Semiconductor Etch Equipment Market size is estimated at USD 23.80 billion in 2024, and is expected to reach USD 34.32 billion by 2029, growing at a CAGR of 7.60%

Research Lab

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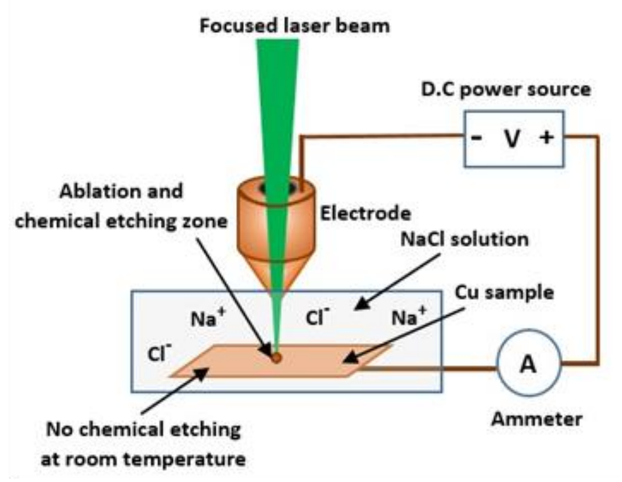

Figure: Schematic showing the mechanism of the hybrid micro-machining

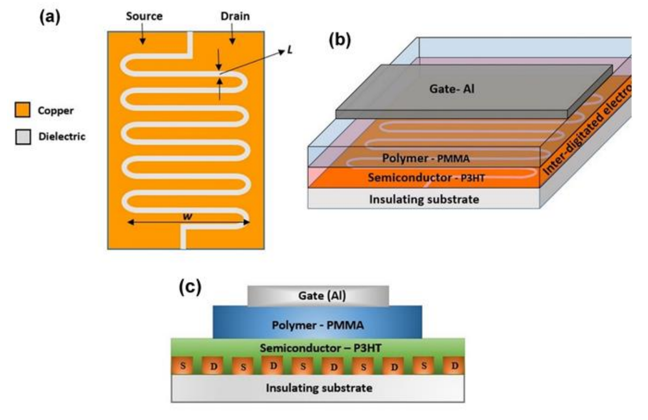

Figure Schematic representation of the (a) inter-digitated Cu based electrode for the source (S) and drain (D) (b) Schematic of the OFET fabricated on top of the inter-digitated Cu electrode(c) Schematic of the cross-section of OFET fabricated on top of the Electrode0

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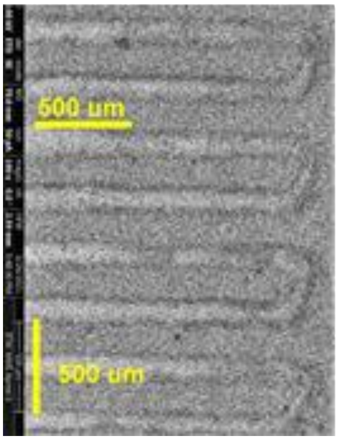

Figure: Scanning electron microscope (SEM) image of the pattern.

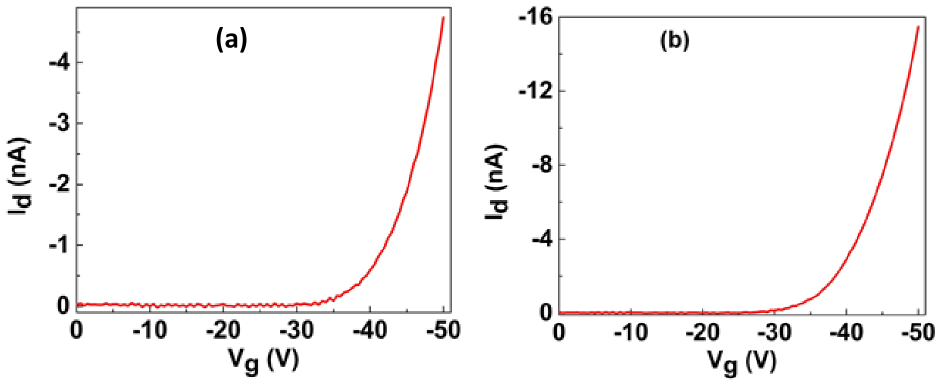

Figure: . The characteristics shows that the fabricated device is operating as a FET.The FET device characteristics **(a)** before annealing were found to be noisy. However, the device characteristics improved with reduction of noise **(b)** after annealing of the device.

Technology

1. • **Submerging a metal film to be etched in a neutral salt solution.**
2. • **Applying a voltage to an electrode unit, below a threshold voltage.**
3. • **Focusing a laser beam through the electrode unit onto the metal film.**
4. • **Irradiating the laser beam onto the metal film to increase the temperature around the ablation zone, along with laser ablation of the metal film**
5. • **Triggering mobility of metal ions in the neutral salt solution for achieving selective chemical etching**
6. • **Achieving hybrid mask-less removal of material from the metal film through laser ablation and laser-activated selective chemical etching**

Key Features / Value Proposition

- The developed hybrid micro-scribing technique is helpful in micro-scribing Cu film on a dielectric insulator without thermal damage to the dielectric substrate.
- The developed method is mask-less and uses non-toxic reagents. Whereas, conventional methods require micro-tool fabrication or mask-based methods with toxic chemicals.
- Overall, the device demonstrated a decent transistor characteristic with acceptable leakage current levels. The field-effect saturation mobility was estimated to be around 10^{-6} cm^2/V s.
- The proposed laser-assisted hybrid scribing is a promising technique for fabricating electrodes for semiconductors. The method is flexible, cost effective and environmental friendly.

Figure: A distinct recast layer was observed when the laser scribing was performed on Cu film in an **(a)** air medium. The surface morphology was adversely affected and the oxide layer was present. However, by employing the scribing in **(b)** NaCl solution, the recast layer formation and thermal damage, as observed in the case of laser scribing in the air, was prevented.

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