IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

FABRICATION OF LARGE SCALE $PbZr_xTi_{1-x}O_3$ (PZT) THIN FILMS BY OFF-AXIS PULSED LASER DEPOSITION (PLD) TECHNIQUE

IITM Technology Available for Licensing

Problem Statement

- PZT is desirable for fabricating electrical devices like power harvesters, sensors, surface acoustic wave devices etc. due to its favorable electrical properties
- PZT in thin film form exhibits lower leakage current density, higher remanent polarization for fast polarization switching, and can sustain high dielectric strength compared to bulk polycrystalline ceramics.
- Developing PZT thin films over large areas is challenging due to the volatile nature of Pb at high processing temperatures and the need to maintain stoichiometry across the entire deposited area.

Technology Category/ Market

Category – Advanced materials

Applications –Sensors, Semiconductors, acoustic devices, power harvesting systems

Industry – Electrical, Manufacturing

Market -Piezoelectric Materials Market size was valued at USD 29.23 billion in 2021 and is poised to grow from USD 30.9 billion in 2022 to USD 48.14 billion by 2030, growing at a CAGR of 5.7% in the forecast period (2023-2030).

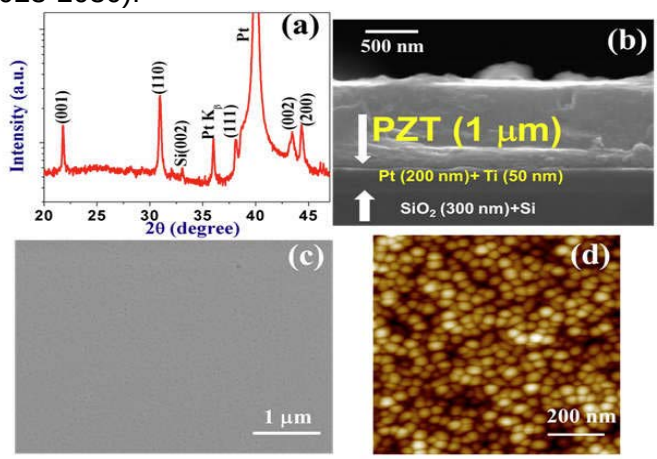

Fig.1 (a) shows XRD pattern of the PZT (48/52) thin film on Pt/TiO2/SiO2/Si substrate, **(b)**Cross- sectional SEM images of the PLD grown PZT thin films coated on Pt/TiO2/SiO2/Si substrate **(c)** SEM image and **(d)** AFM topography image of the large area thin films

Technology

The present invention discloses a method involves the fabrication of high-quality large-scale $PbZr_xTi_{1-x}O_3$(PZT) thin films on a platinum-coated silicon substrate.

Composition and Preparation:PZT thin films are prepared from stoichiometric quantities of the oxide powders PbO, ZrO2, and TiO2 through a solid-state reaction route

Raster Mechanism:
A programmable raster mirror is utilized and positioned above the quartz window for precision and deposition

Laser Beam Scanning:
The programmable rastered laser beam is fixed with a scan rate of 300 steps/sec

Scanning Pattern:
•starts from the edge of the target, moves towards the center of the 2-inch rotating PZT target, and then reverses its direction.

Incidence Angle: The laser beam is directed onto the target with a specific incidence angle of 45 degrees.

Chamber Conditions and Annealing:
Partial pressure of 0.3 mbar of oxygen (O2) is maintained inside the chamber, followed by deposition, and 60-minute post-deposition annealing to form PZT thin films

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•In the said method the mirror is rastered across the large diameter of the ablated target, contributing to the precision of the deposition process.
•The said programmable rastered laser beam sweeps across the rotating target, covering the entire 2-inch target surface area.
•Further, the crystalline large-area PZT thin films acquired by the said method, wherein the cooling rate during annealing is set at 10 degrees Celsius per minute
•The lateral homogeneity over the large area has been demonstrated by recording polarization maps at the different locations with different electrode sizes of the polycrystalline films

Intellectual Property

- **IITM IDF Ref. 1574**
- **IN 458560-Granted**

TRL (Technology Readiness Level)

TRL- 3, **Experimental proof of concept**

Key Features / Value Proposition

Technical Perspective

- The invention relates to ferroelectric large area PZT thin films, grown on oriented Pt coated Si substrate using off-axis pulsed laser deposition (PLD) with a beam rastering mechanism.
- This method combines specific deposition conditions, scanning patterns, and post-treatment processes to produce large-scale, high-quality PZT thin films

User Perspective

- Large area PZT thin films are used in under-water SONAR devices, power harvester, sensors, acoustic devices, MEMS etc
- The interface between the as-grown large PZT thin films and the Pt coated Si substrate is well defined, flat and sharp

Images

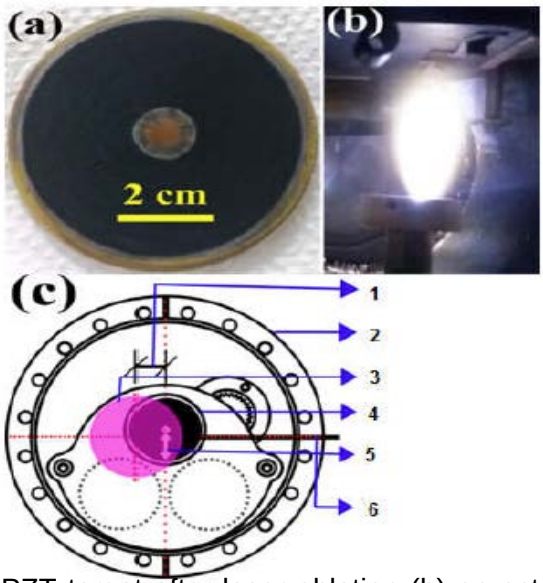

Fig. 2 (a) picture of two inch PZT target after laser ablation (b) an actual photograph of the plume during rastering mechanism (c) schematic representation of the rastering mechanism for growth of large area PZT thin films with levelling , 1) off-axis about 19mm between the center of the rotating substrate and the centre of the ablated target, 2) outerdiameter of the chamber, 3) 3 inch substrate holder, 4) 2 inch target holder, 5) rastering directionfrom the edge of the rotating target to the centre and then backward and 6) laser direction i.e.the laser falls on the target with an incidence angle of 450.

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