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Optical Properties Of Hafnium Oxide Films Grown By Laser Assisted Molecular Beam Deposition (LAMBD)

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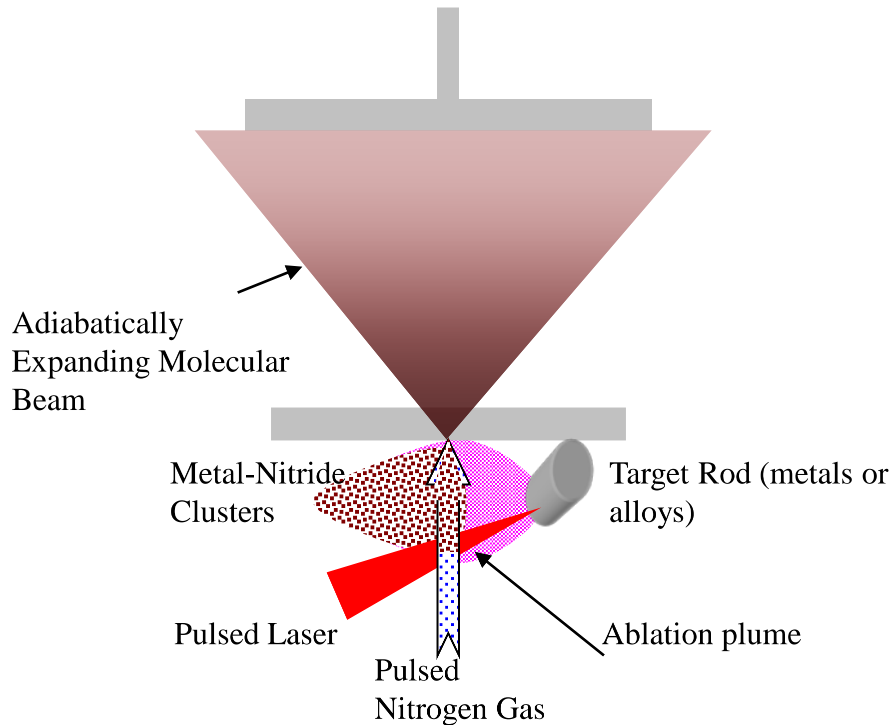
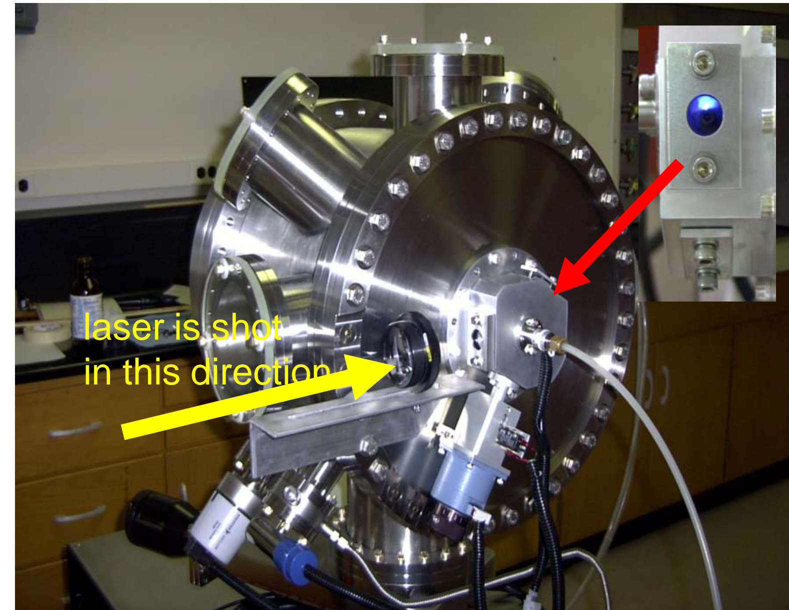
Introduction

- Both film properties and device performance are affected by thin film processing technique and parameters. Among them, low temperature processing technique is always desirable.
- Laser assisted molecule beam deposition (LAMBD) technique offers opportunity to deposit various films at low temperatures, even at room temperature, which makes possible to deposit dielectric film on polymer or other temperature sensitive substrates.
- Spectroscopic ellipsometry technique provides non-destructive method to characterize and qualify the films processed with LAMBD.

LAMBD Process





LAMBD Process Schematic

LAMBD Process Chamber with View Port

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The LAMBD Advantage

LAMBD is a marriage of:

MOLECULAR BEAM DEPOSITION
and
PULSED LASER DEPOSITION

- **Can deposit on low T rated substrates such as polymers.**
- Low Energy influx of the depositing species – no surface damage to substrate.
- Thickness precisely controlled by number of laser pulses.
- Superior Surface Morphology to conventional PLD.
- LAMBD sources can be cheaply implemented directly in existing laser deposition systems, providing new life to a dying technology.

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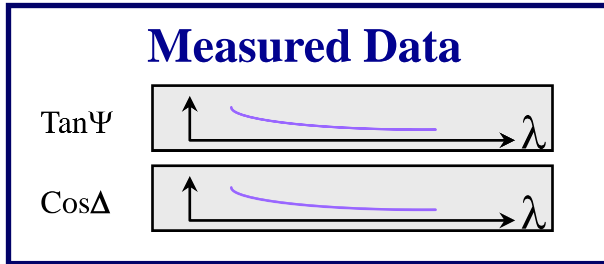
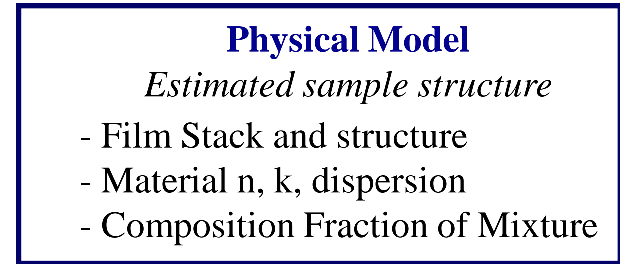
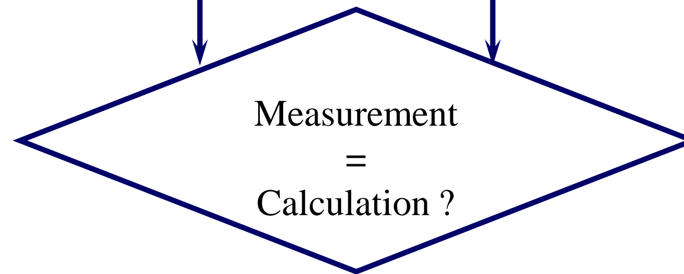
$$\rho = \frac{R^P}{R^S} = Tan\,\psi \cdot e^{j\Delta} = f(n_i, k_i, d_i \cdots)$$







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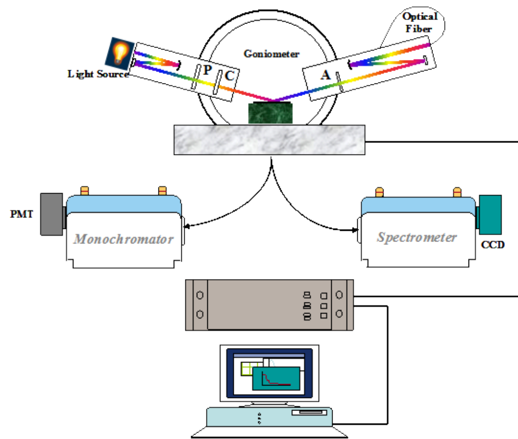

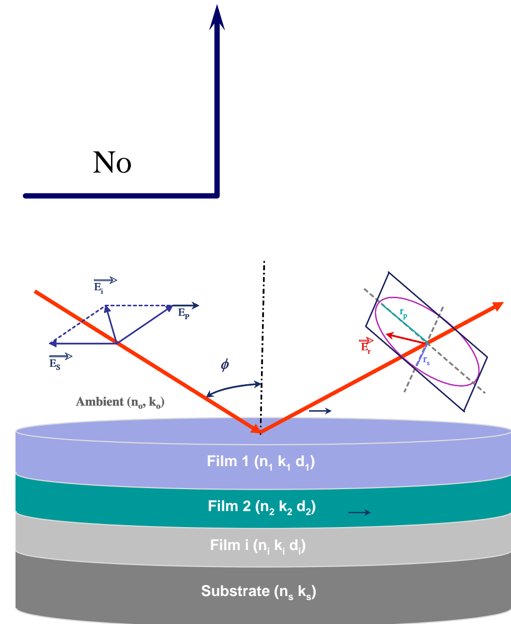

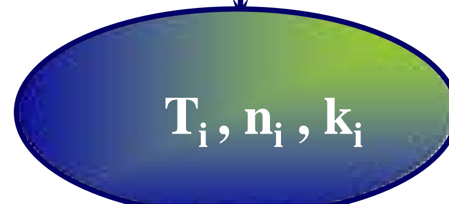

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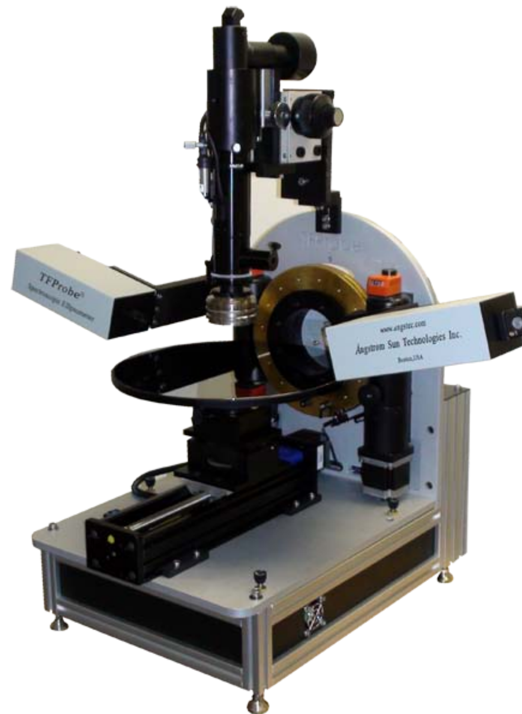
Variable Angle Spectroscopic Ellipsometer



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HfO_2 High K Dielectric Results

Processing Conditions

1. Laser energy: 100 mJ/pulse
2. O_2 pressure: 12 psi
3. Substrate distance: 263 mm

Sample ID	Laser Shots	Substrate Temperature	Thickness	Effective Rates (nm/kshots)
030404.1	20K	350 ^oC	558 nm	27.9
030804.1	10K	150 ^oC	387 nm	38.7
030804.3	5K	32 ^oC	256 nm	51.2

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HfO_2 High K Dielectric Results

1.48
1.44
1.40
1.36
1.32
1.28

Refractive Index, N

N-35C-5K
N-150C-10K
N-350C-20K

250 750 1250 1750

Wavelength, nm

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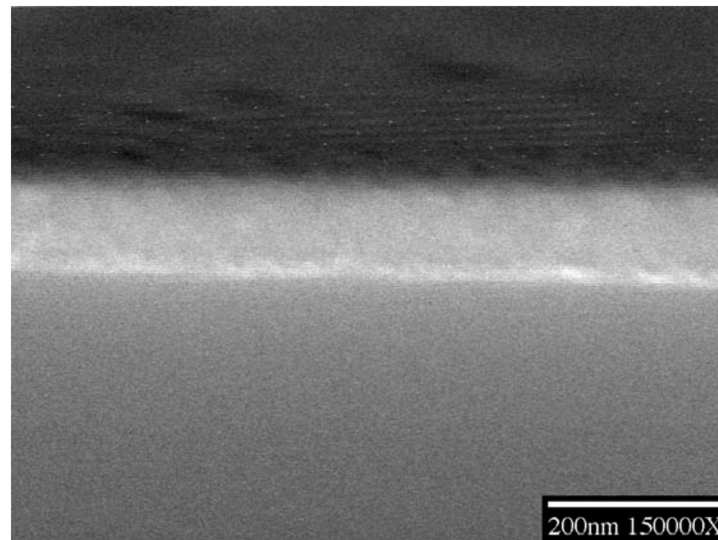
HfO_2 High K Dielectric Results

HfO_2

- High Density SEM image of HfO_2
- ε_r between 1.7-2.2 observed



Summary

- High K HfO2 films were successfully prepared with LAMBD technique.
- The films processed with LAMBD were characterized with variable angle spectroscopic ellipsometer.
- It seems that film density increases with processing temperature.