NoRHDia- Project-Preparation-Meeting
June 26, 2007
GSI, Darmstadt

HETEROEPITAXIAL DIAMOND ON IR/YSZ/SI(001): A NEW MATERIAL FOR DETECTOR APPLICATIONS

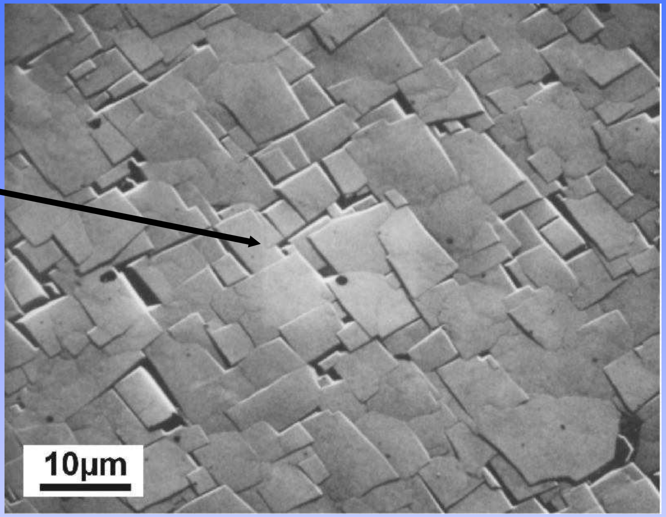
Matthias Schreck

Universität Augsburg, Institut für Physik,

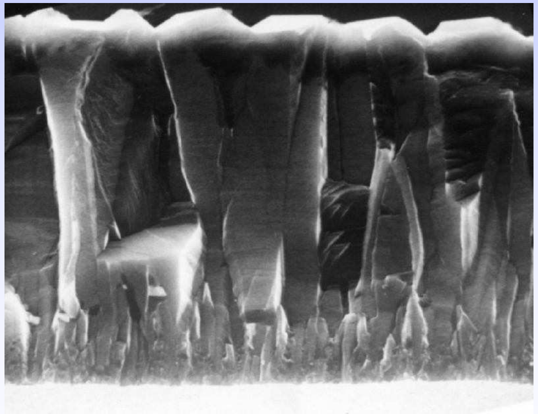
D-86135 Augsburg (Germany)

EPITAXIAL DIAMOND FILMS ON Si(001)

Surface:
coplanar,
azimuthally
oriented {001}-
facets



cross section:
columnar growth

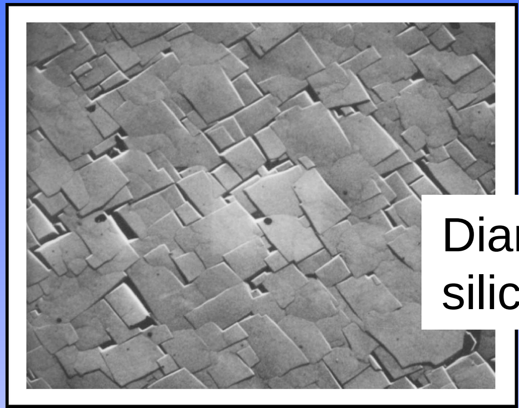


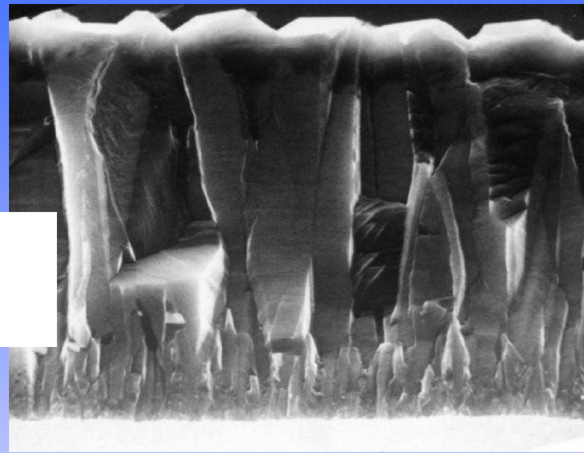
grain coarsening

COMPARISON: DIAMOND ON Si $\Leftrightarrow$ DIAMOND ON Ir/$SrTiO_3$

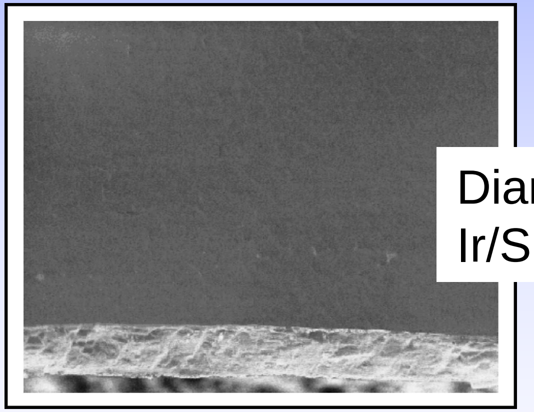
The film surface

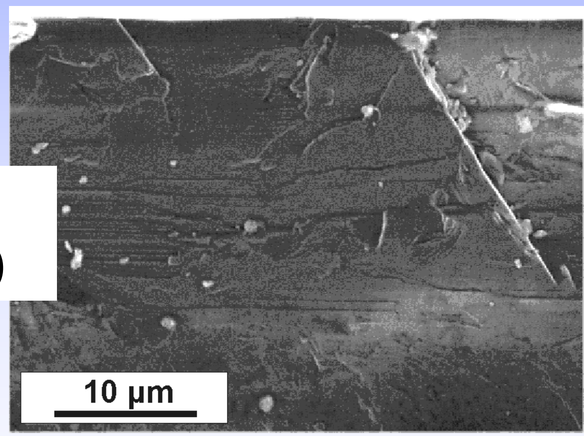
The cross section





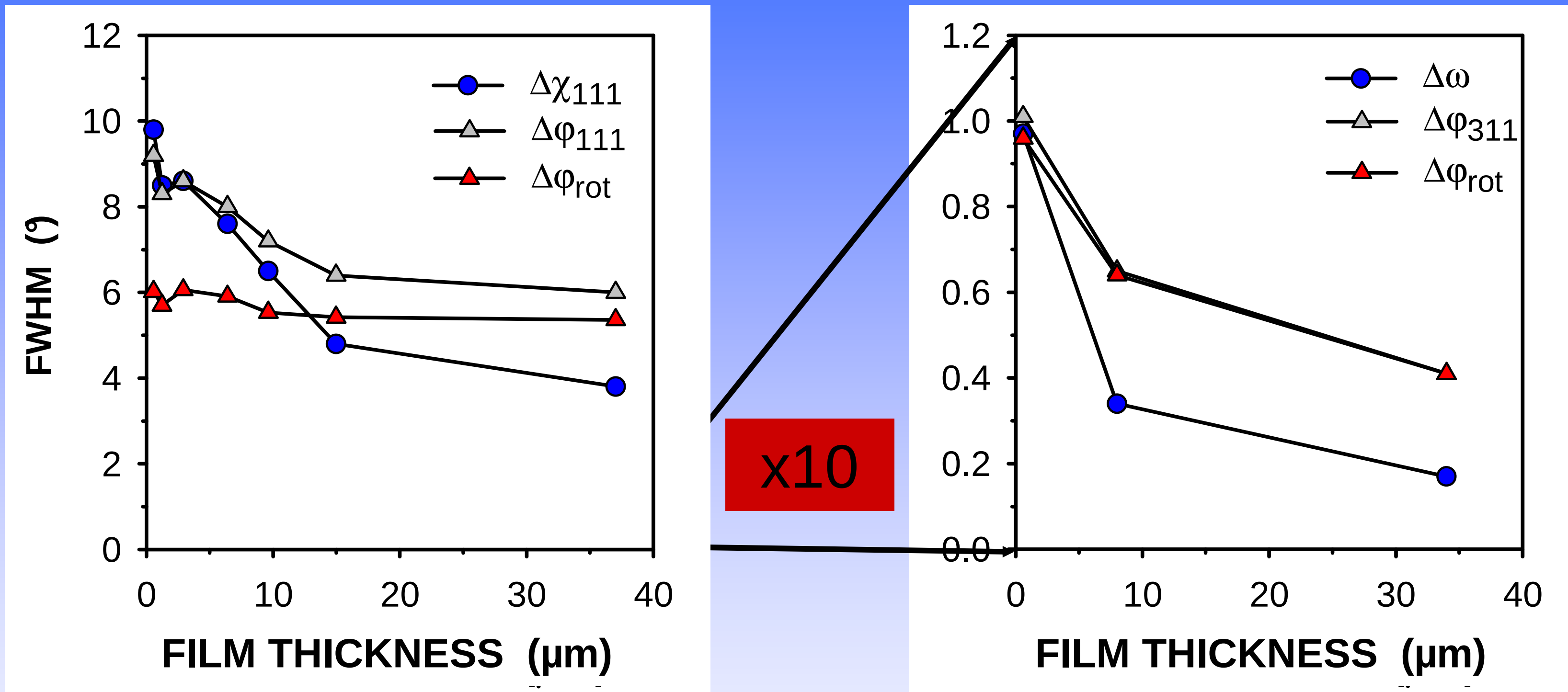
Diamond on silicon





Diamond on Ir/$SrTiO_3$(001)

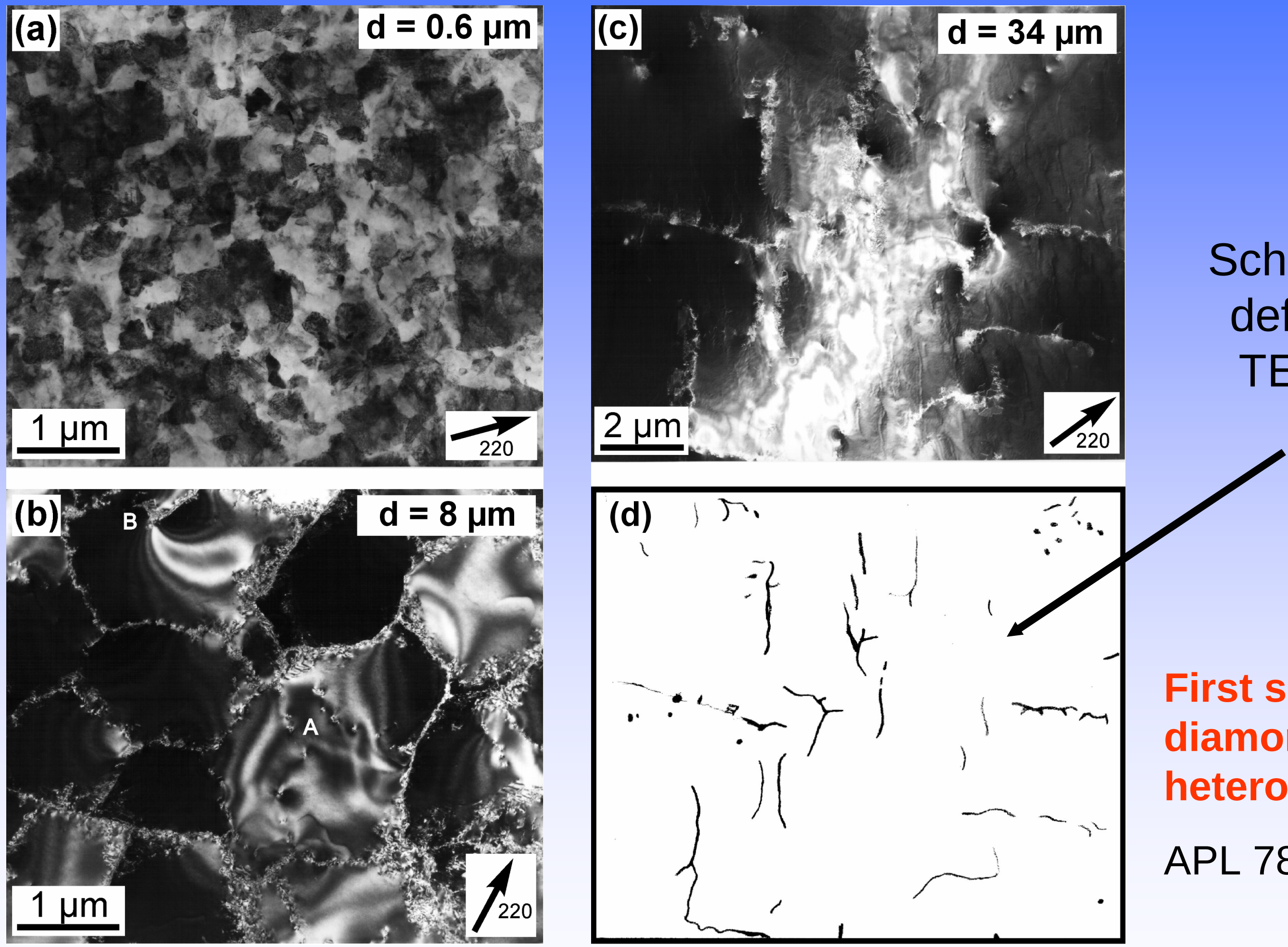
DIFFERENCES IN THE TEXTURE DEVELOPMENT: DIAMOND ON Si ⇔ DIAMOND ON Ir/$SrTiO_3$



→ One order of magnitude lower mosaicity

→ Tilt and Twist decrease with thickness

INTERNAL DEFECT STRUCTURE: TRANSMISSION ELECTRON MICROSCOPY (TEM)



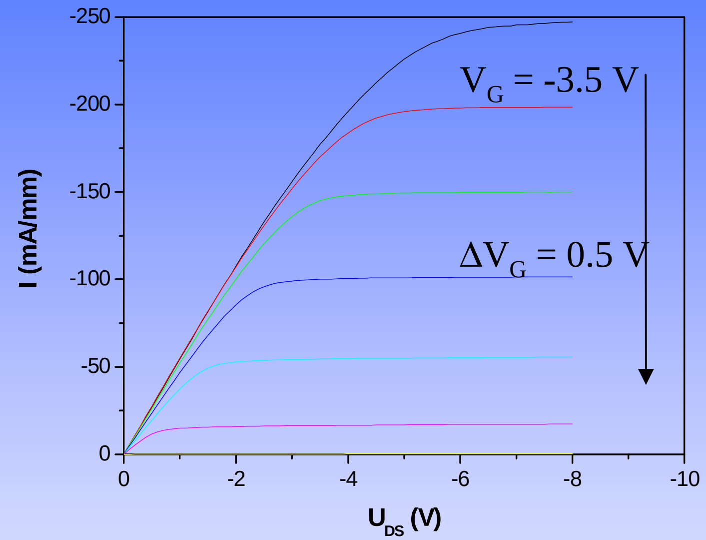
Schematic sketch of defect bands from TEM image in (c)

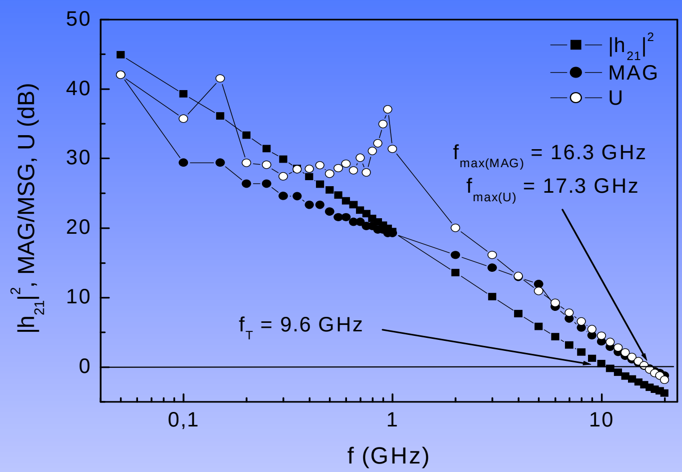
First single crystal diamond films by heteroepitaxy!

APL 78 (2001) 192

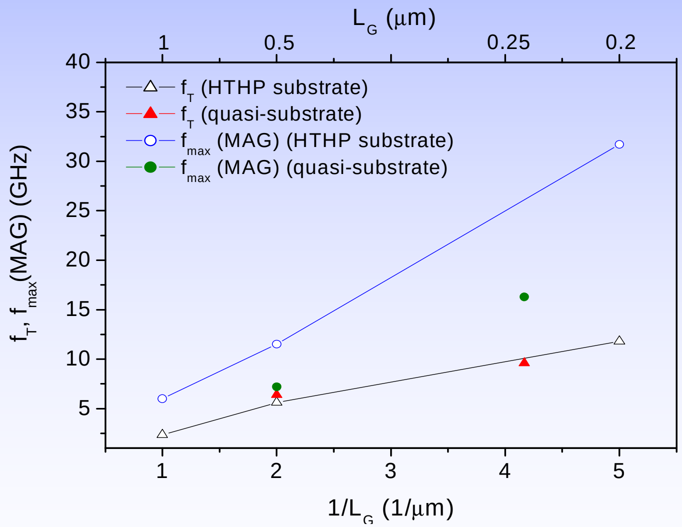
FIELD EFFECT TRANSISTORS REALISED ON Dia/Ir/$SrTiO_3$(001) SAMPLES

FET output characteristics



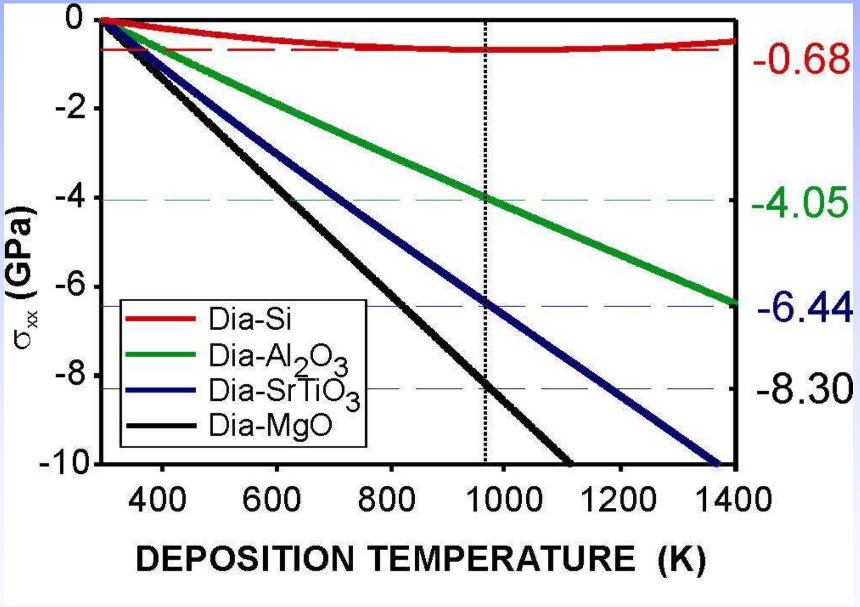


Results: transconductance $g_{(mMAX)}$ = 97 mS/mm
high break down field strength
Operation at microwave frequencies demonstrated
Properties approach values measured for homoepitaxial layers!!



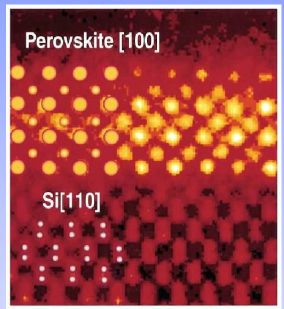
WHAT IS THE IDEAL SUBSTRATE FOR THE GROWTH OF LARGE AREA IRIDIUM FILMS AND THE GROWTH OF DIAMOND??

- Oxide crystals facilitate the deposition of single crystal metal layers
- Some are available in large size at affordable costs (e.g. sapphire)
- However: The fit of thermal expansion coefficients is poor

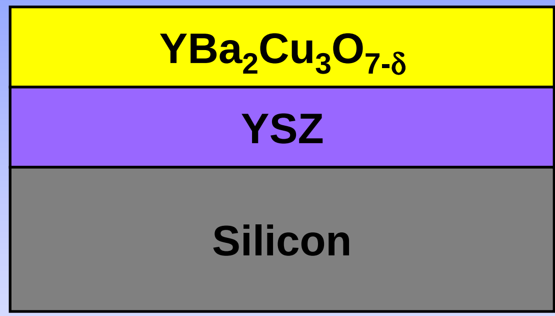


OXIDE BUFFER LAYERS ON SILICON AS
HIGH-K DIELECTRICS & EPITAXIAL GROWTH SURFACE

R. A. McKee, F. J. Walker, and M. F. Chisholm: *Crystalline Oxides on Silicon: The First Five Monolayers*, Phys. Rev. Lett. 81 (1998) 3014.



A. Bardal, M. Zwerger, O. Eibl, J. Wecker, Th. Mathee, *$YBa_2Cu_3O_{7-\delta}$ films on Si with Y-stabilized ZrO_2 and Y_2O_3 buffer layers: High resolution electron microscopy of the interfaces* Appl. Phys. Lett. 61 (1992) 1243.



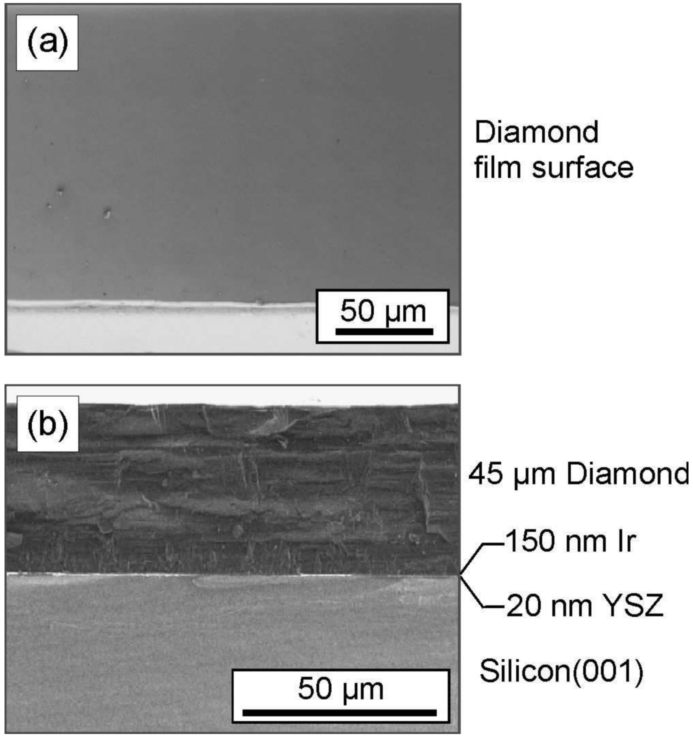
Deposition method:

Molecular beam epitaxy (MBE)

Deposition method:

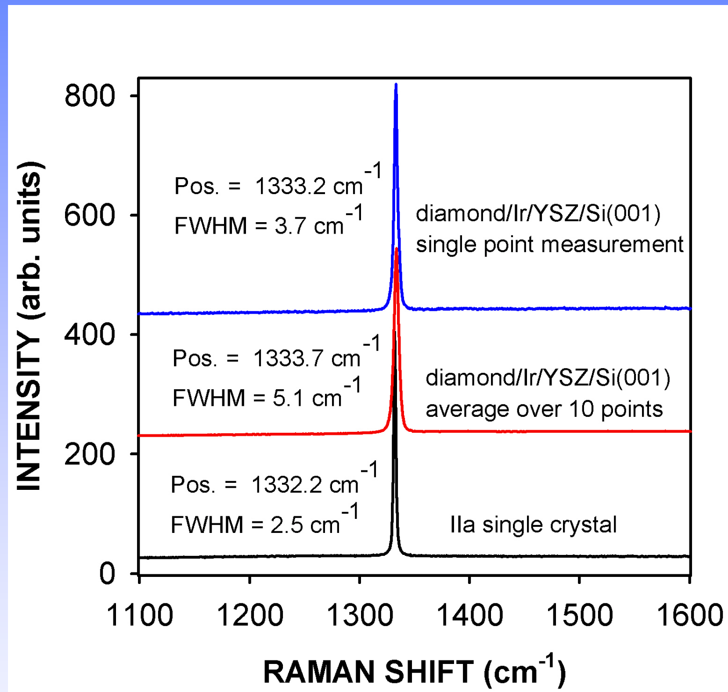
Pulsed laser deposition (PLD)

THICK DIAMOND FILMS ON Ir/YSZ/Si(001)



45 µm thick diamond film with good adhesion to the substrate

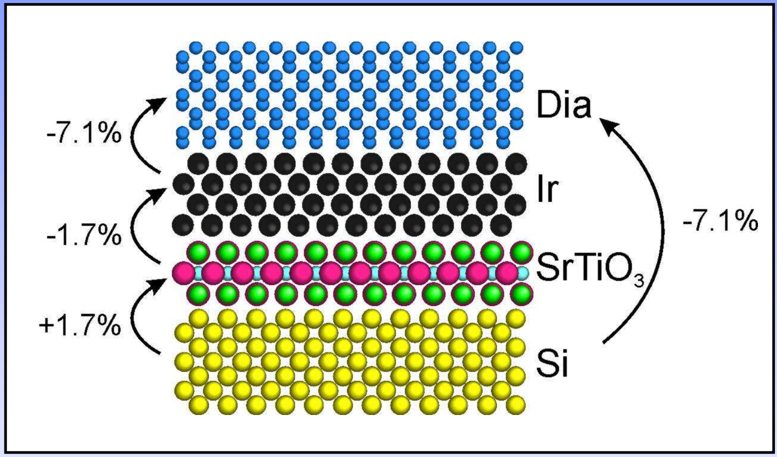
µ-Raman measurements



HOW IS THE HUGE LATTICE MISFIT ACCOMODATED IN THE TWO CASES?

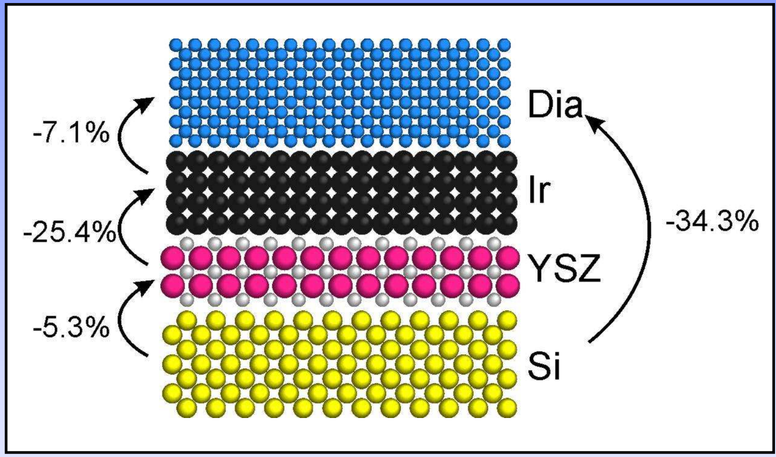
1) Dia/Ir/$SrTiO_3$/Si(001)

(45° rotation of $SrTiO_3$ vs. Si)



2) Dia/Ir/YSZ/Si(001)

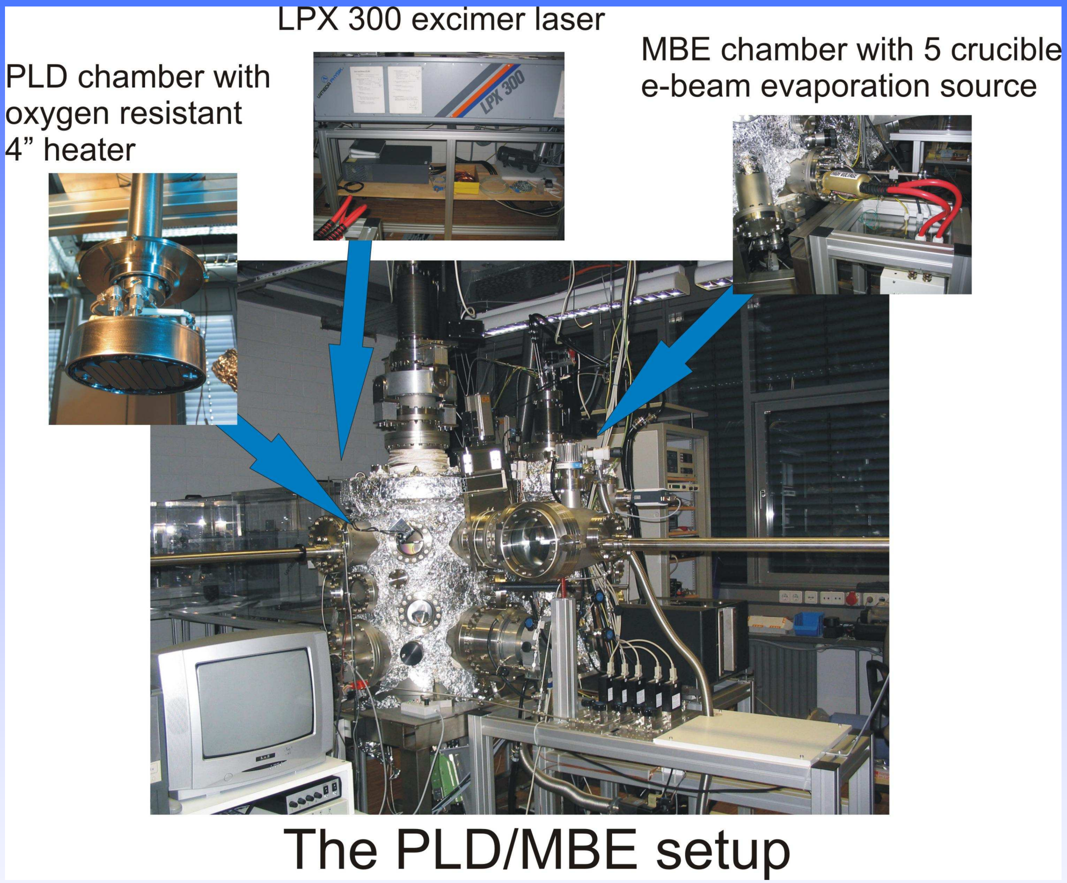
(cube on cube)



Current status:

4 inch wafers of Ir/YSZ/Si(001) have been realized

THE SETUP FOR THE GROWTH OF LARGE AREA EPITAXIAL METAL LAYERS ON SILICON



Implementation of RHEED for in-situ study of growth of metal films

LARGE AREA EPITAXIAL METAL LAYERS ON SILICON: CURRENT STATE

Neither YSZ nor Ir --

But indispensible for successful film growth !

YSZ/Si(001)

Ir/YSZ/Si(001)