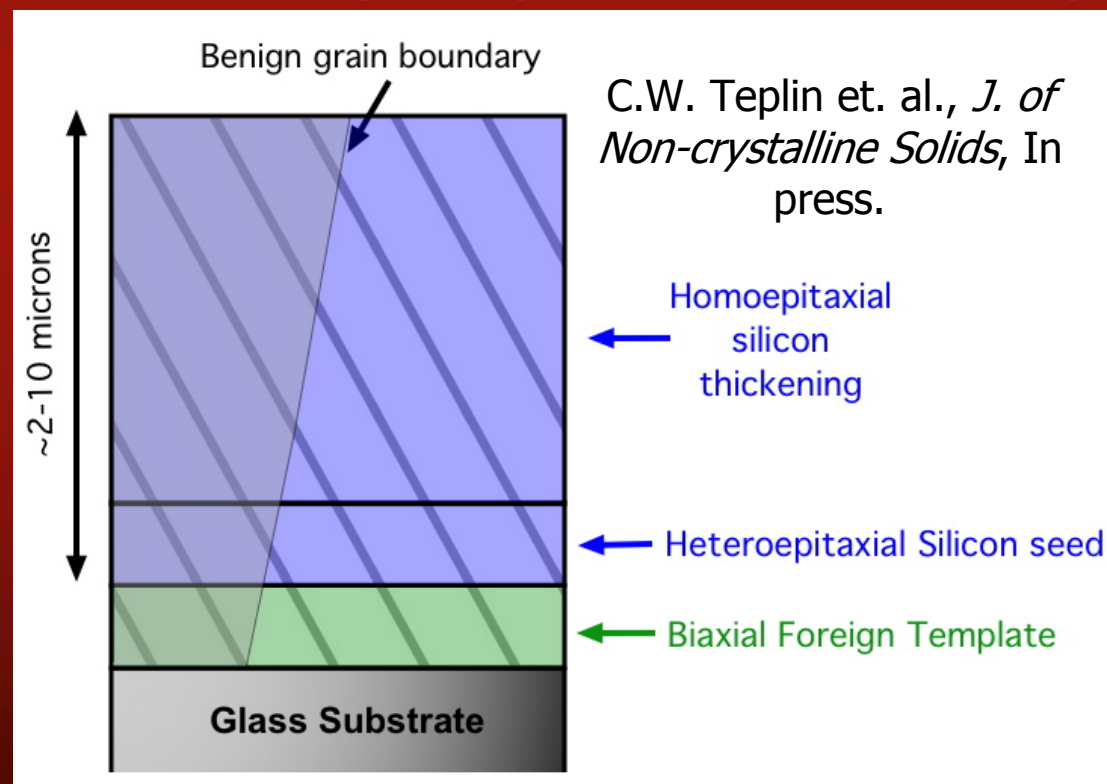


## Motivation

- Thin-film polycrystalline silicon solar cells exhibit higher efficiency when the grain boundaries are low-angle
- Heteroepitaxy on biaxially aligned cerium oxide may improve efficiency



Solar cell template concept: may work well with lattice-matched (200) CeO<sub>2</sub>

**Goal: Sputter biaxially textured CeO<sub>2</sub> on glass as a model template layer**

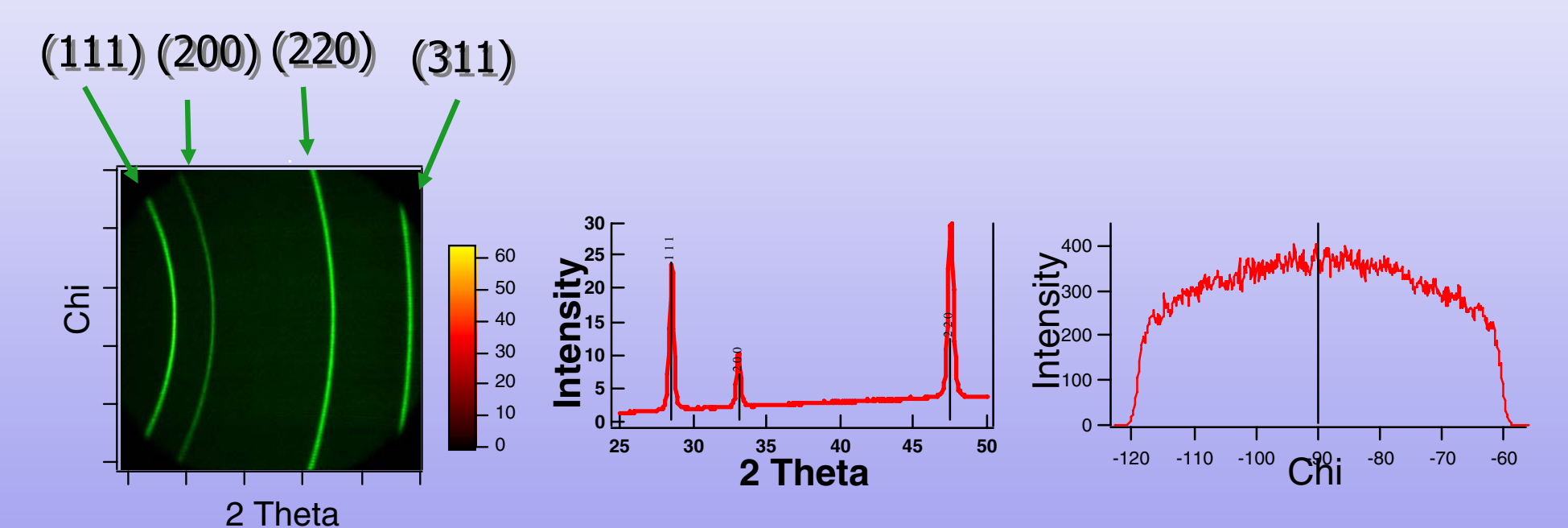
## Experimental Approach

- Deposit CeO<sub>2</sub>
  - RF magnetron sputtering
  - Ceramic ceria target
  - Room temperature
  - Inclined Substrate Deposition
- Examine orientation using X-Ray diffraction
- Sputtered cerium oxide tends to orient (111) towards the gun and parallel to the surface; can we change the orientation?

## 2D X-Ray Detector Images Explained

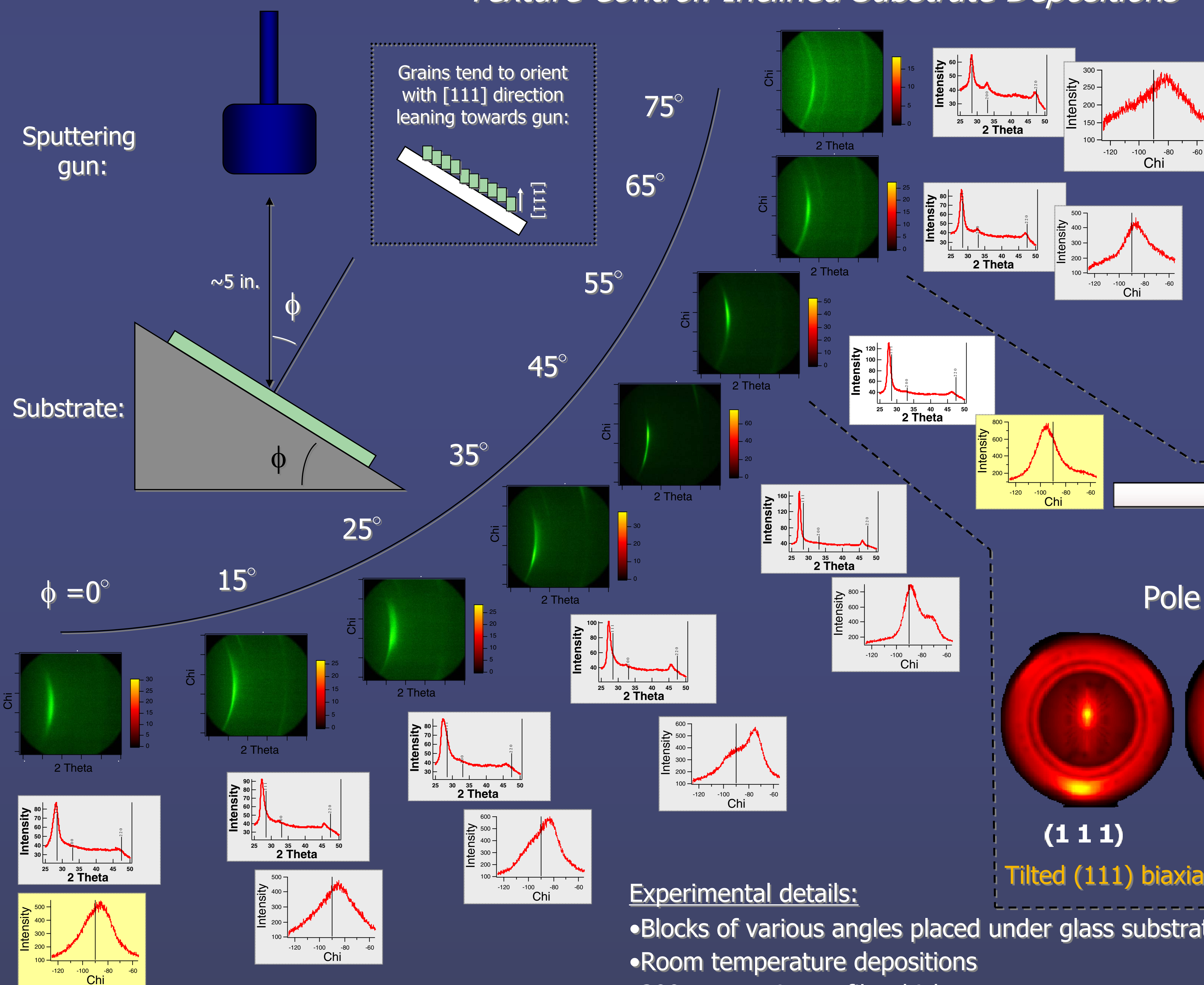
- Horizontal direction is standard 2θ axis
- Vertical direction is χ, similar to ω in rocking curves
- χ-plots shown for (111) peak

Example powder diffraction images (CeO<sub>2</sub> target):



- Localization in χ means texturing
- A negative shift in χ means grains are tilted towards gun
- A shift in θ indicates lattice strain (oxygen vacancies)

## Texture Control: Inclined Substrate Depositions



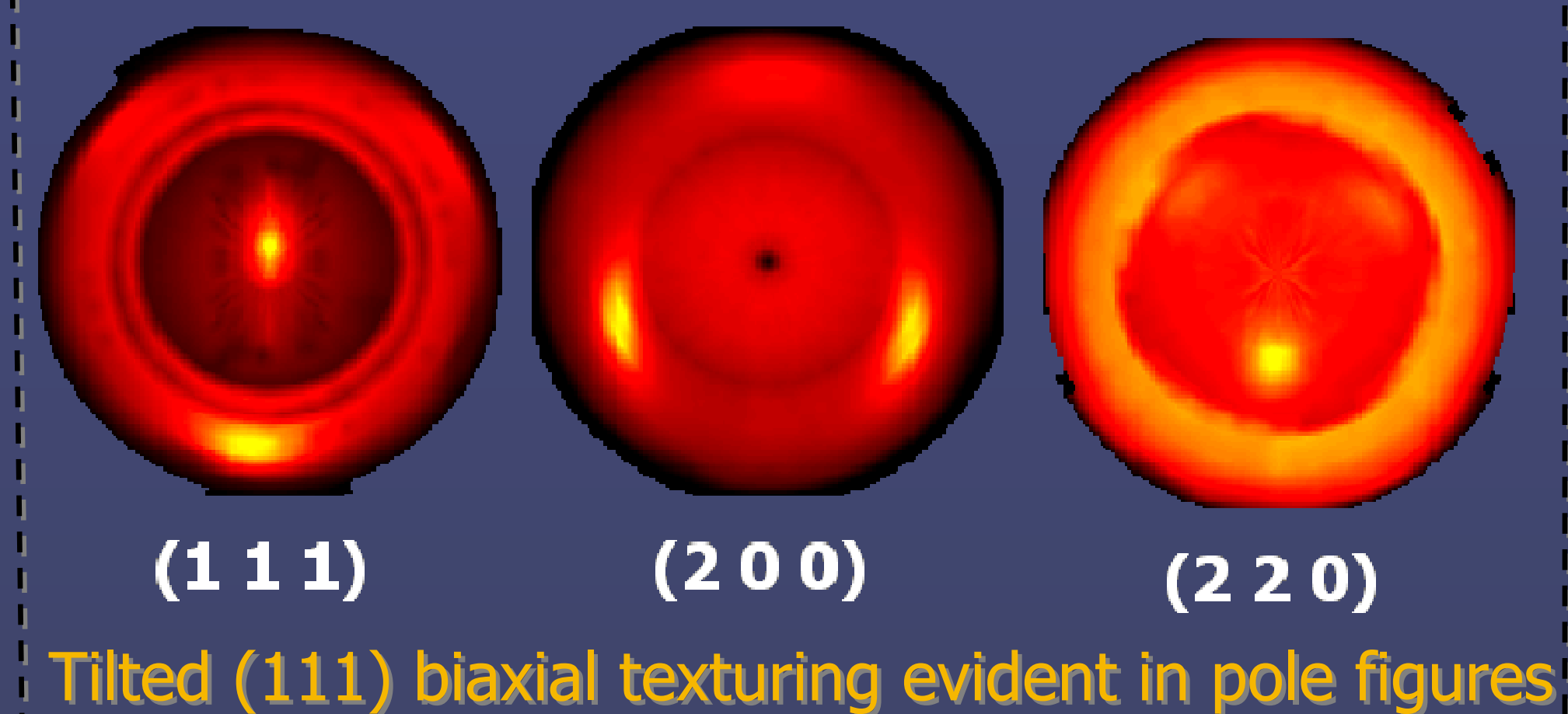
## Observations

Texture initially tends towards uniaxial [111] direction at normal incidence (wire texture)

χ-plots indicate grains angle towards gun at low angles

Another [-111] normal direction exists at φ = 70°; biaxial (111) texturing emerges when {111} points towards both the gun and substrate normal

## Pole Figures at φ = 55°



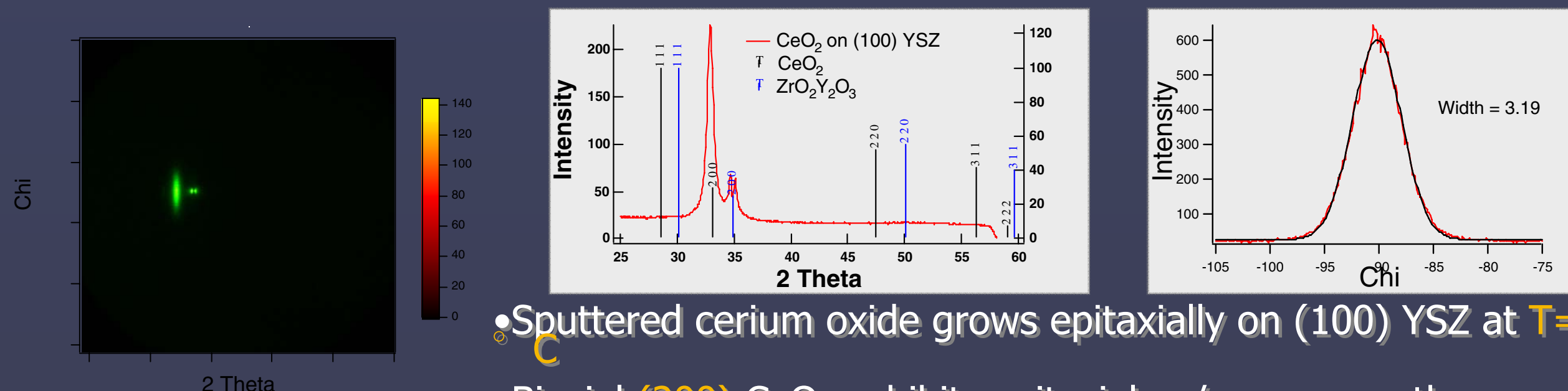
Tilted (111) biaxial texturing evident in pole figures

## Experimental details:

- Blocks of various angles placed under glass substrates during sputtering
- Room temperature depositions
- 300 nm maximum film thickness

## Texture Control: Room Temperature Epitaxy on YSZ

CeO<sub>2</sub> sputtered on single-crystal substrates of yttria-stabilized zirconia



• Sputtered cerium oxide grows epitaxially on (100) YSZ at T=25

- Biaxial (200) CeO<sub>2</sub> exhibits epitaxial columnar growth
- (200) texturing evident even when inclining the substrate

## Conclusions

- Texture control is possible in cerium oxide by epitaxial growth or adjusting the substrate angle
- Biaxial (111) texture emerges with inclined angle depositions on glass
- Biaxial (200) texture emerges by epitaxial growth on YSZ