AVS-50th-2003:

Ultra-thin Cr_xMo_{1-x} films on MgO:

Preparation and characterization

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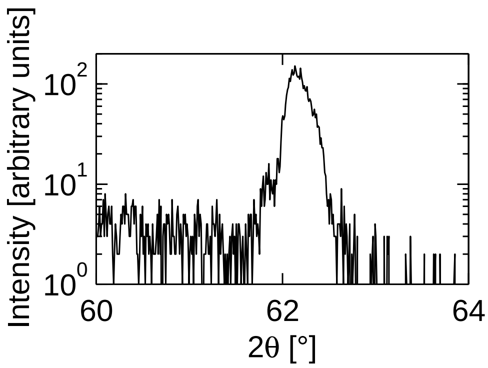
Introduction

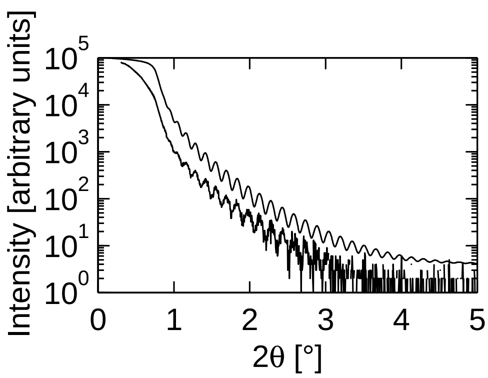
- We report on the preparation of lattice matched heteroepitaxial films in a DC magnetron sputtering discharge
- Cr_xMo_{1-x} thin films were grown on MgO (1 0 0) substrate, choosing the composition of the binary metal alloy such that the inter-atomic distance along the $< 011 >$ direction approximates the lattice constant of MgO
- Ex situ X-ray diffraction (XRD) and low angle X-ray reflectivity measurements were performed to determine the film structure, film thickness, as well as the surface and interface roughness
- The resistivity of the films was measured ex situ using a four-point-probe

X-Ray Diffraction



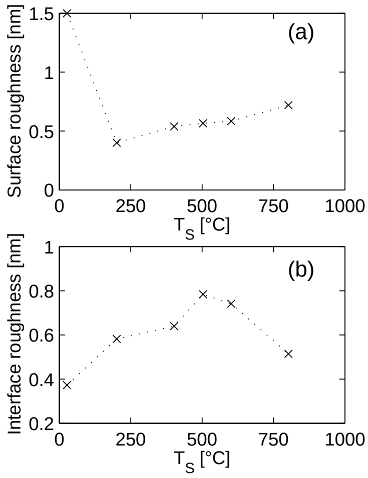
- High angle X-Ray Diffraction measurement for a Cr_xMo_{1-x} grown at 200°C, with $x \approx 0.63$
- As the growth temperature was raised the surface and interface roughness increased

X-Ray Reflectometry



- X-Ray Reflectometry curve
- The lower curve is the measured data and the upper curve is the fit for a Cr_xMo_{1-x} grown at 200°C, with $x \approx 0.63$
- The upper curve is vertically offset for clarity

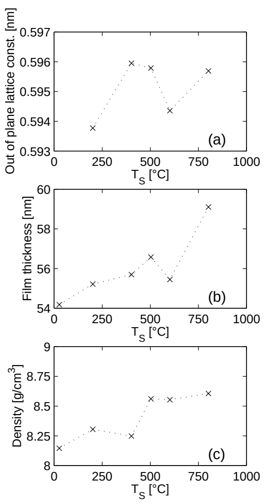
Film properties



- Cr_xMo_{1-x} alloy, with $x \approx 0.63$
  - (a) Film surface roughness
  - (b) film/substrate interface roughness

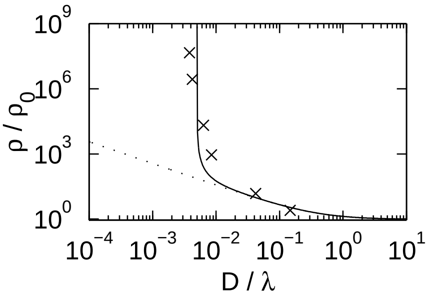
  versus growth temperature

Film properties



- Cr_xMo_{1-x} alloy, with $x \approx 0.63$
  - (a) Out-of-plane lattice constant, i.e. in the direction perpendicular to the substrate surface, (b) film thickness, (c) film density, versus growth temperature

Film electrical resistivity



- Thin Cr_xMo_{1-x} film electrical resistivity divided by bulk resistivity versus thickness divided by the electron mean free path
- The composition of the films is $x \approx 0.63$, and they are deposited at 200°C growth temperature
- The dotted line shows the Sondheimer-Fuchs model for thickness dependent resistivity and the solid line shows Namba's model for 0.5 nm roughness

Summary

- We determine the optimum growth temperature to be 200°C
- Using this temperature 0.4 - 15 nm thick films were prepared
- The resistivity dropped rapidly with increasing thickness
- The resistivity vs. thickness data was found to be well described with Namba's model, which includes film roughness as a parameter
- Indications were found that the films grow in the Frank-van der Merwe mode, which excludes the formation of three-dimensional islands
- The low roughness and absence of three-dimensional island growth growth allows the preparation of films suitable for the construction of well defined nanoscale structures