Ultrathin MgO films on Fe(001): growth, morphology and implementation in magnetic tunnel junctions

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Phenomena in the magnetic tunnel junctions:
- Tunneling Magnetoresistance (TMR)
- Interlayer Exchange coupling (IEC)

are directly dependent on the quality of the MgO tunnel barrier and the interfaces between Fe and MgO.

M. Mizuguchi et al. found that MgO barriers thinner than 5ML were imperfect [1]. In the study of M. Klaua et al. the monolayer of MgO was completed in the 3.8 ML film, showing nearly perfect layer-by-layer growth of MgO onto Fe [2].

The aim of this study was to prepare and characterize ultrathin MgO layers on Fe(001) with the greatest attention paid on the continuity of MgO films.

### Results I: growth & morphology

**Does the morphology of Fe layer influence the quality of MgO deposited on it?**

STM measurements were performed for different Fe layer preparation methods. All MgO films were deposited at RT.

**Fe oxidation at the interface**

- **Fe high deposition temp. (400 °C), No annealing:**
- **Fe surface:**
- **plus 1 ML MgO:**

- **Fe RT deposition:**
- **high annealing temp. (450 °C):**
- **0.9 ML Fe:**
- **300 Å MgO:**
- **100 Å MgO:**

**Fe oxide formation at the interface**

- **Fe surface:**
- **plus 0.5 ML MgO:**

**MgO as thin as 0.5 ML (~1 Å) seems to create a continuous oxide layer.**

All the shown STM scans are 100x100 nm.

### Results II: magnetism

**Is FeO layer formed when MgO is deposited on Fe?**

CEMS measurement shows the chemical state of $^{57}$Fe atoms located at the MgO/Fe interface.

**IEC measurements for a wedged sample using MOKE:**

Remanence and saturation fields derived from MOKE loops:

- **Antiferromagnetic coupling exists for two Fe layers separated by MgO barrier as thin as 2 Å.**

### Conclusions

- **Morphology of Fe layer does not influence directly the quality of MgO barrier.**
- **Judging on STM, MgO as thin as 0.5 ML seems to create a continuous oxide barrier.**
- **CEMS measurements prove that almost 0.5 ML of Fe at the interface is oxidized in the form of FeO, which is consistent with previous studies [3].**
- **IEC investigation using MOKE shows that 2 Å (1ML) MgO film creates a continuous oxide barrier. Based on STM and CEMS results we can conclude that the continuous oxide layer is composed of both MgO and FeO.**