

# Spintronics in Novel Systems

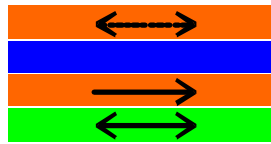
MINT Spring review 2003

---

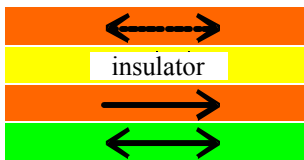
**THE UNIVERSITY OF ALABAMA**

Center For Materials For Information Technology  
An NSF Materials Research Science and Engineering Center

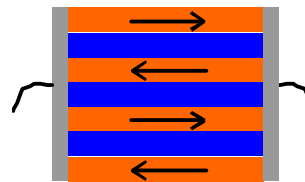
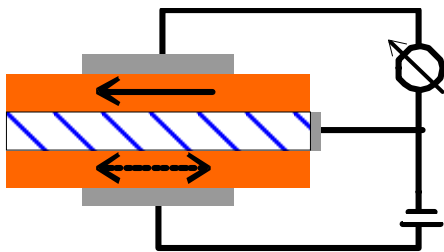
# Spin-dependent transport materials



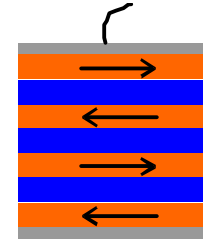
spin valve



magn. tunnel junction



CIP

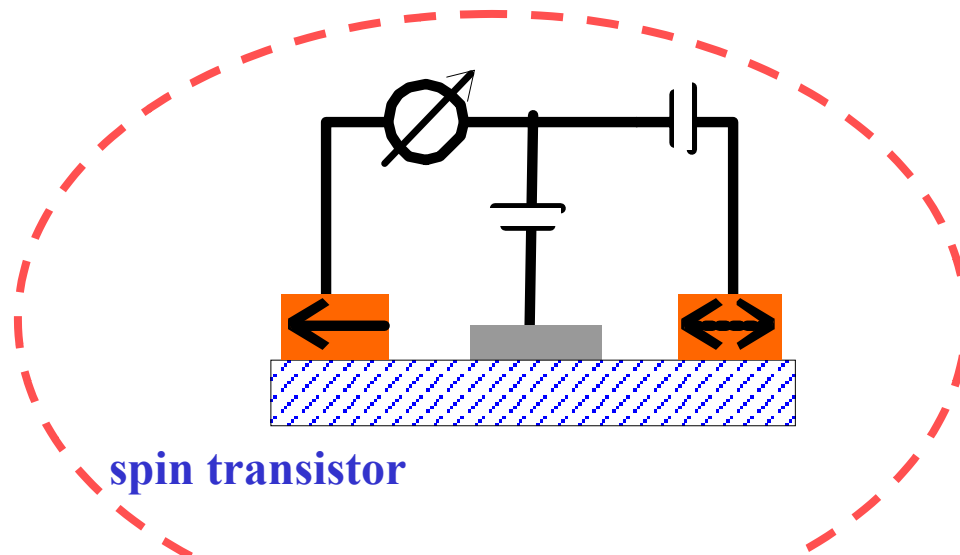


CPP

GMR multilayer



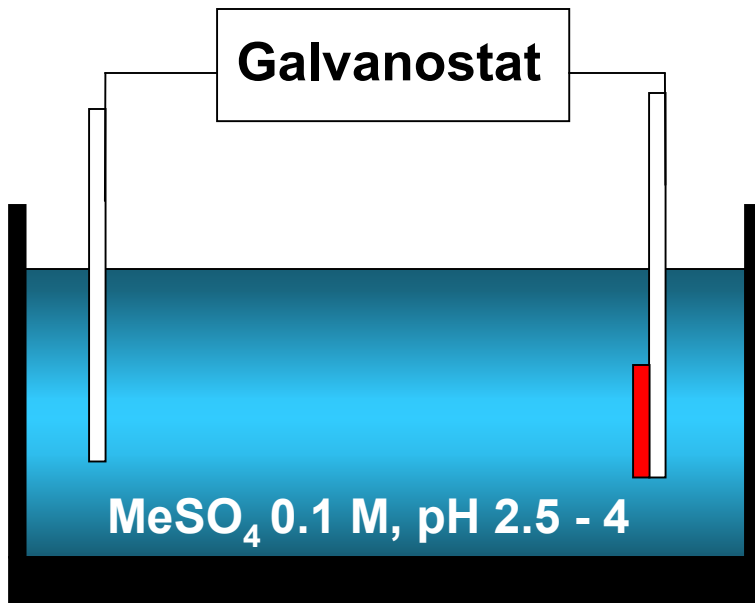
domain wall resistance



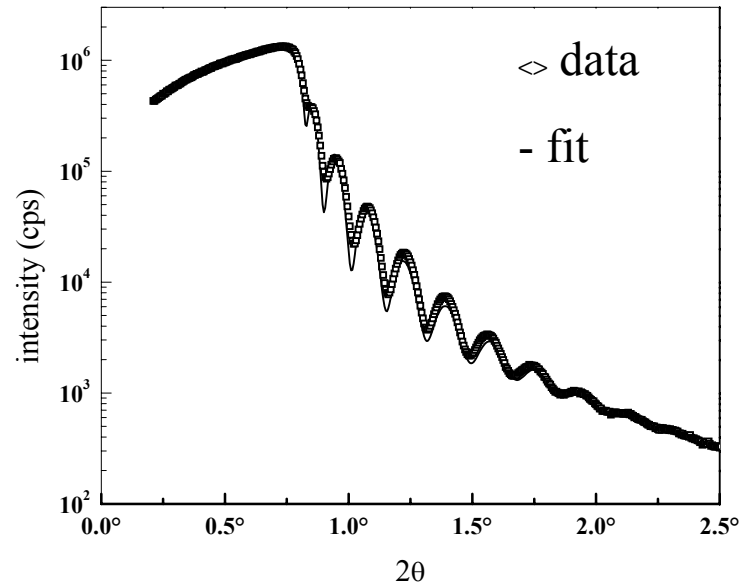
spin transistor

## Electrodeposited Ni, Co, Fe on GaAs

### Experimental



### Thickness calibration



smooth layers

### Growth

- n-GaAs (001), (011) -  $10^{17}$  cm<sup>-3</sup> Te
- Back contact: Ga/In eutectic
- Graphite counter electrode
- EG&G 273A Galvanostat
- Room Temperature

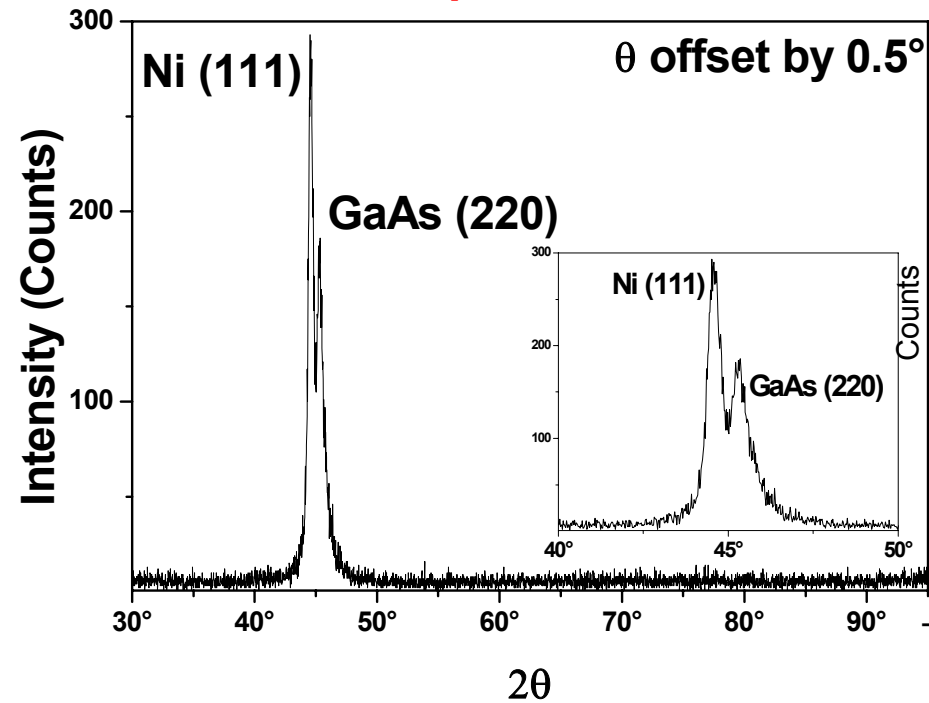
THE UNIVERSITY OF ALABAMA

Center For Materials For Information Technology  
An NSF Materials Research Science and Engineering Center

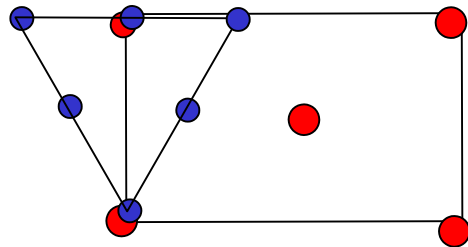
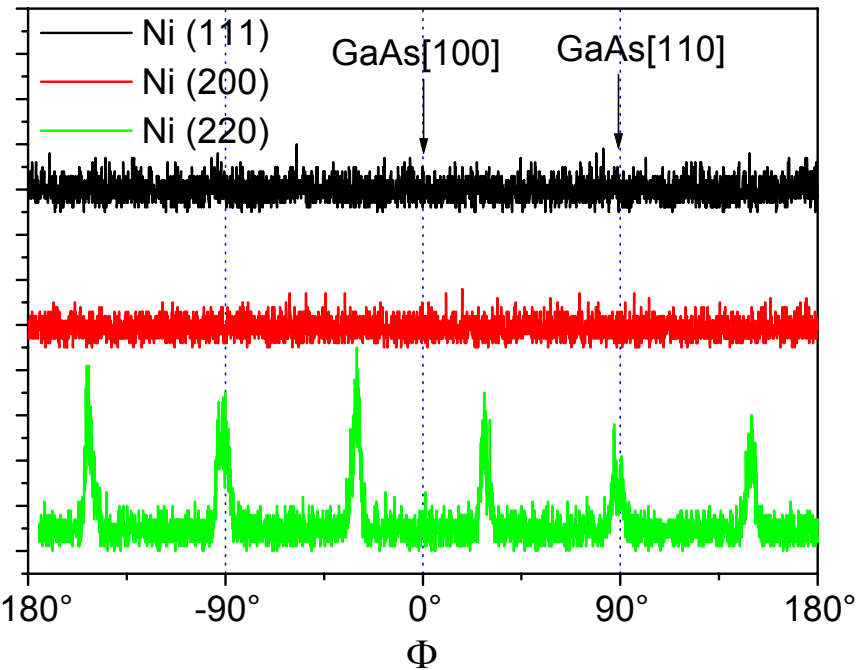
# Electrodeposited Ni, Co, Fe on GaAs

## Crystalline Structure (XRD) - Ni on GaAs (011)

**Out of plane:**



**In Plane:**

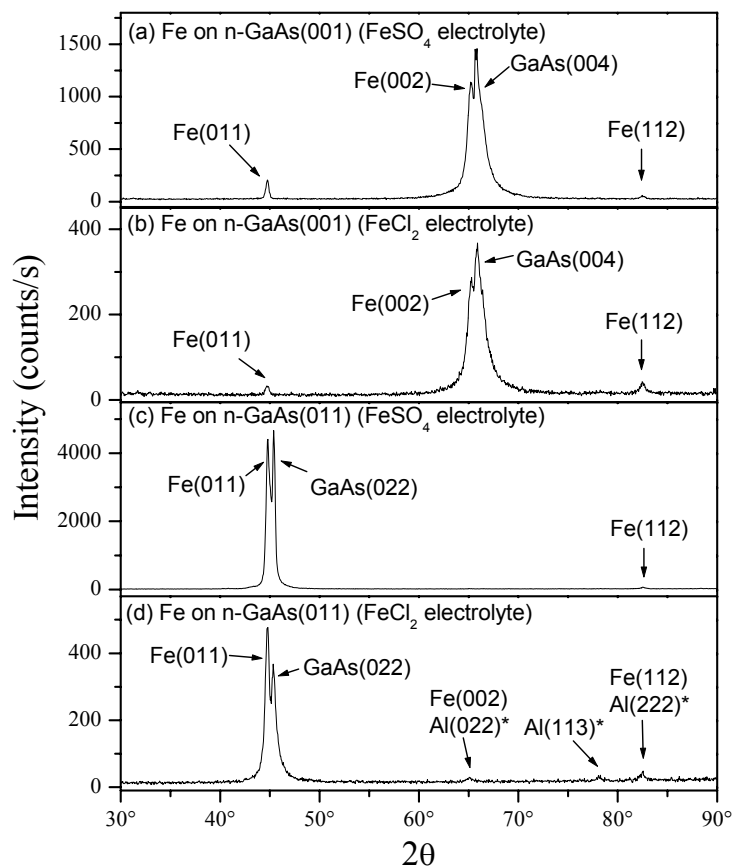


**Ni(111)//GaAs(011)**  
**Ni[110]//GaAs[110]**

# Electrodeposited Ni, Co, Fe on GaAs

## Crystalline Structure (XRD) - Fe on GaAs (001),(011)

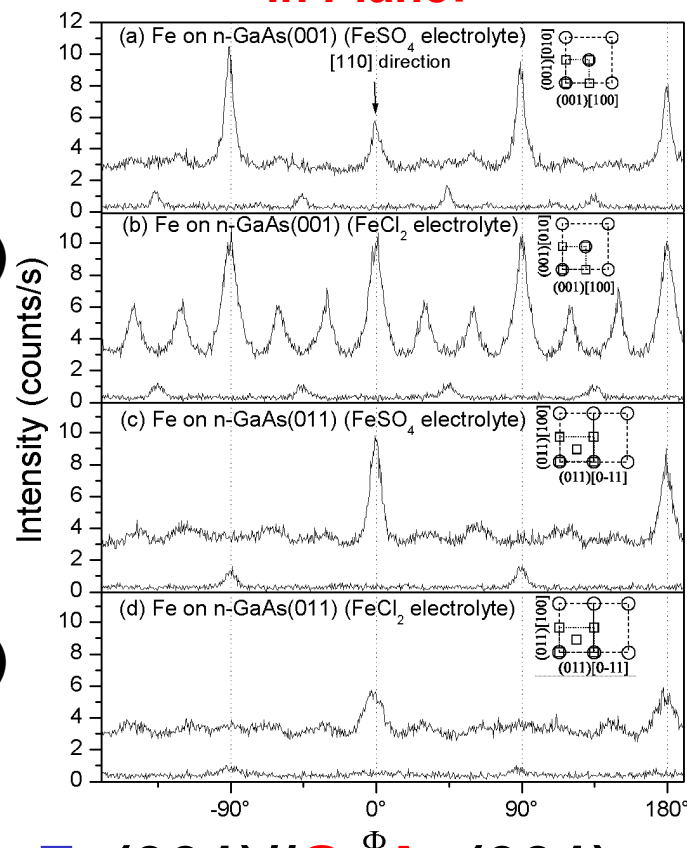
**Out of plane:**



**Fe(001)/  
GaAs(001)**

**Fe(011)/  
GaAs(011)**

**In Plane:**

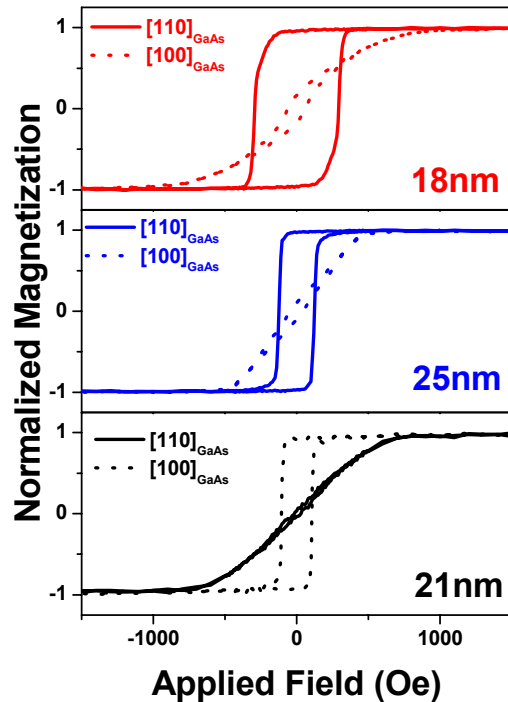


**Fe(001)//GaAs(001)  
Fe[010]//GaAs[010]**

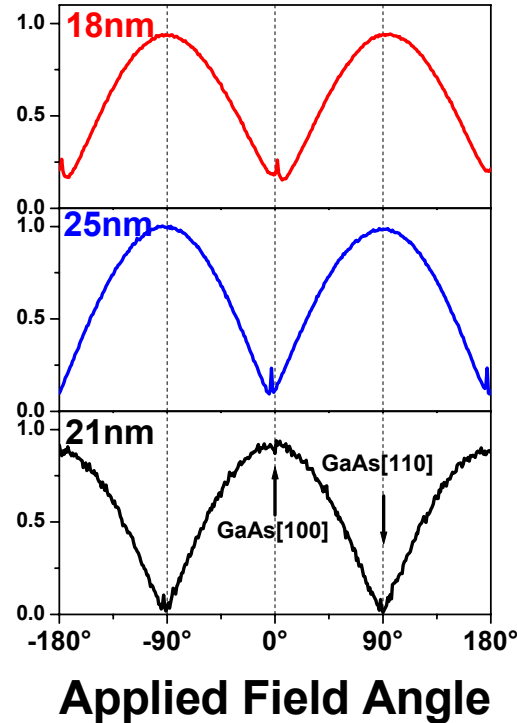
# Electrodeposited Ni, Co, Fe on GaAs

## Magnetic Properties

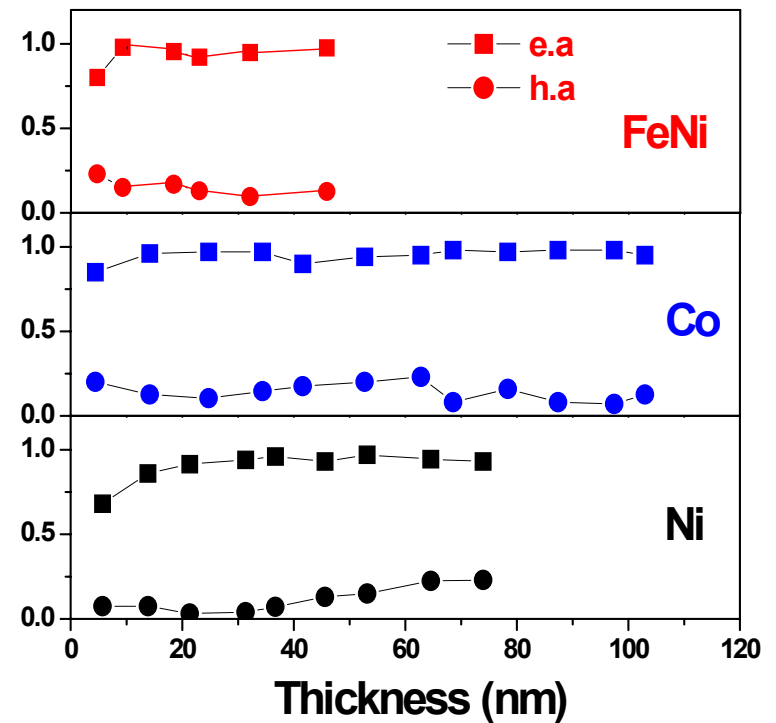
### Hysteresis



### Remanence



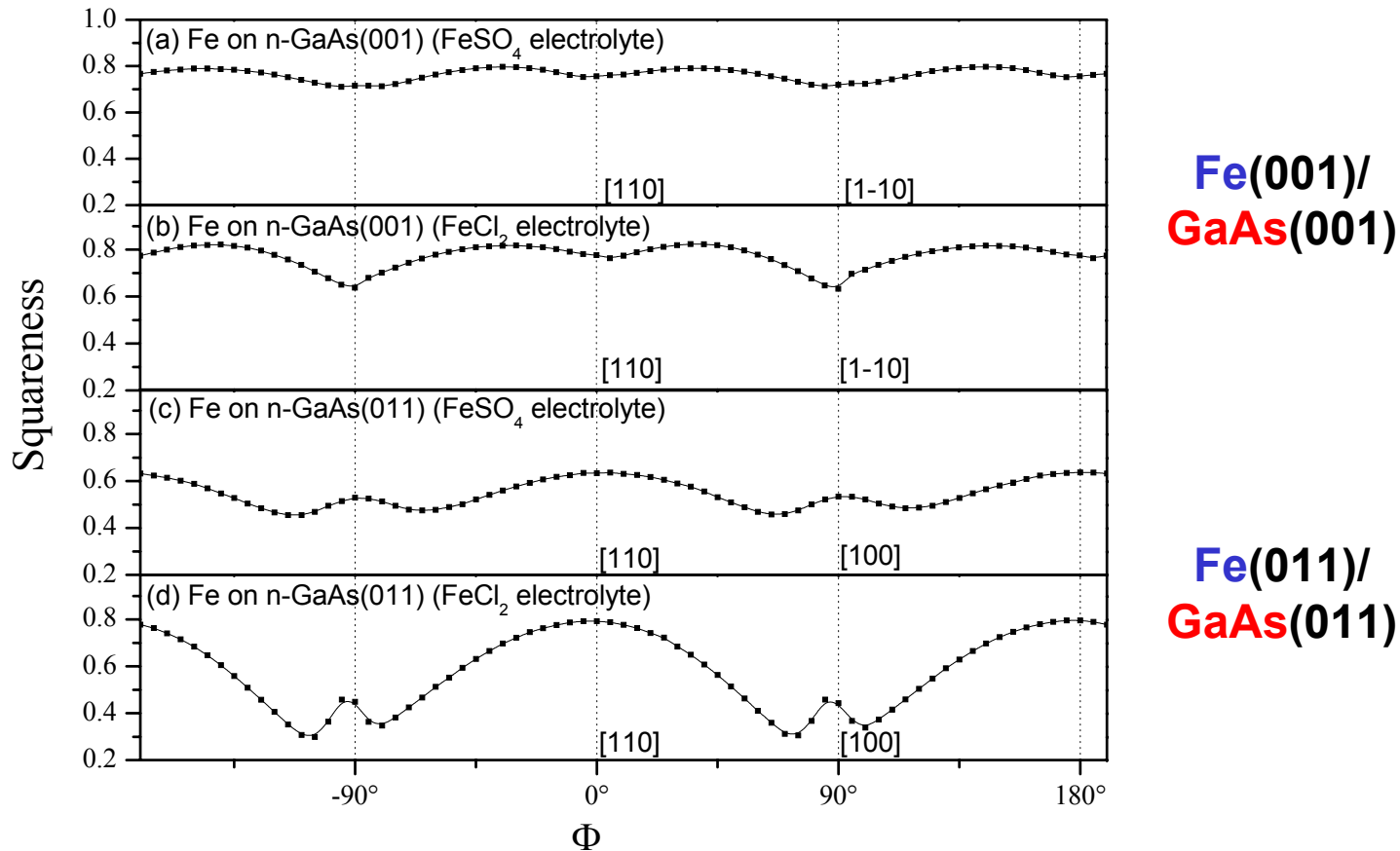
### Squareness



**Uniaxial anisotropy** → e.a. [001]<sub>GaAs</sub> for Ni  
 → e.a. [011]<sub>GaAs</sub> for Co and FeNi

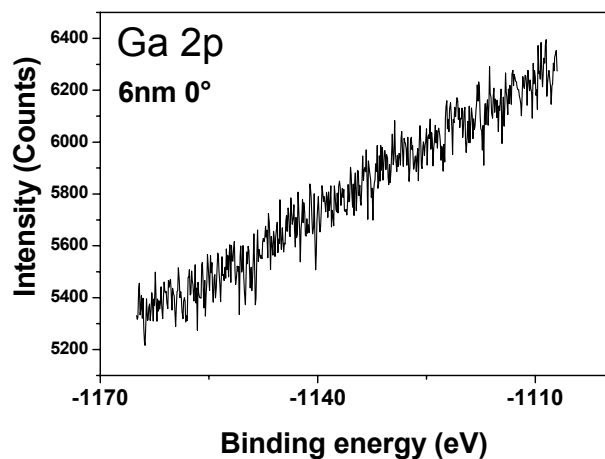
# Electrodeposited Fe on GaAs Magnetic Properties epitaxial Fe

## Remanence

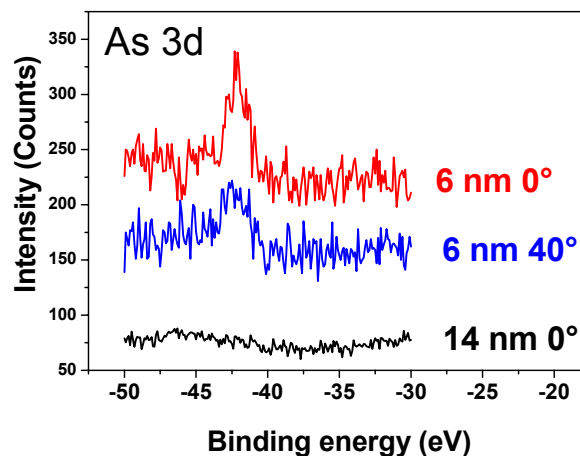


# Electrodeposited Ni, Co, Fe on GaAs

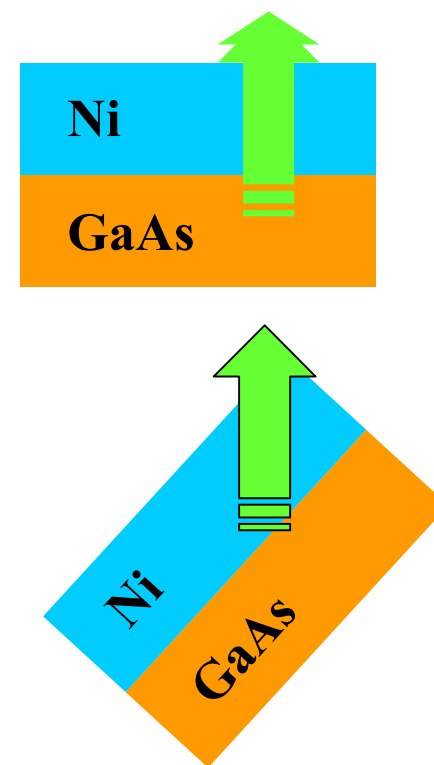
## Interface intermixing: XPS analysis



mfp @ 370eV(Ga 2p)  
in Ni = 0.75nm

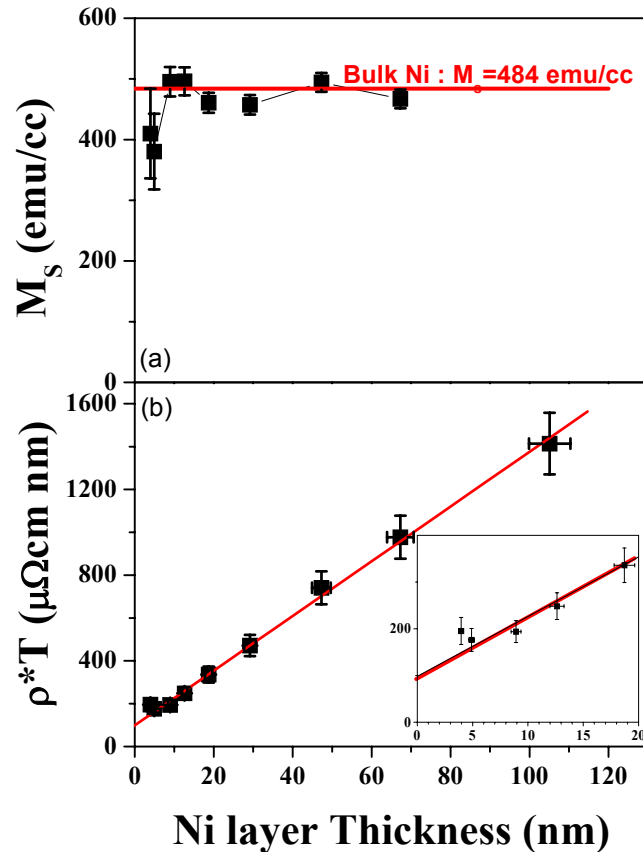


mfp @ 1444eV(As 3d)  
in Ni = 1.9nm



- No Ga, As at the surface
- No or little diffusion at interface

# Electrical and magnetic measurements



**Bulk Ni :  $M_s=484$  emu/cc**

**Fuchs model:**

$$\rho(T) = \rho_{\infty} + (3/8) (1-p)(\rho_{\infty} \times l_{\infty}) / T$$

with the bulk resistivity  $\rho_{\infty}$ ,  
 the bulk mean free path  $l_{\infty}$ ,  
 the “reflectivity” coefficient  $p$

$$\rho_{\infty} = 12.8 \mu\Omega\text{cm}$$

**→ No or little intermixing at the interface**

**Electrodeposited Ni, Co, Fe on GaAs**  
**Future Work**

- **Investigation of Ni/GaAs Schottky barrier properties**
- **Spin injection from Ni contacts into GaAs**
- **Electrodeposition on patterned p-n type GaAs,Si**