Self-aligning growth of Co on doped semiconductors

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Motivation

We know that electrodeposition produces quality FM films on n-type semiconductors.

We know that electrodeposition hardly works on p-type semiconductors.

We thought combination of p and n doping areas should lead to a self aligned growth of FM layers.

 Objective:

1) p-n surface pattern replicated by electrodeposition

2) Locally enabling growth through illumination.
Experimental Growth:

- Substrate: n(500nm)-p-GaAs (Zn+In doped) p-Si (Te doped)
- $10^{18}$ cm$^{-3}$ (n-type) and $10^{17}$ cm$^{-3}$ (p-type)
- Back contact: Ga/In eutectic
- EG&G 273A Galvanostat
- Room Temperature
- Graphite counter electrode

Electrolyte:

- Co, Cu sulfate solution 0.1 M
- pH 2.5
Doping-induced electrodeposition

Physical mechanism:

Schottky diode

No current flow in the reverse bias
→ p-type is blocking
Doping-induced electrodeposition

**Substrate preparation:**

After development of the photoresist

GaAs is etched chemically up to the p-region using NH$_4$ + H$_2$O$_2$, then the photoresist is removed → substrate is ready for plating

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Doping-induced electrodeposition

Electrodeposition process:

Applied potential $V = -1V$

→ Selective deposition on n-type GaAs
Doping-induced electrodeposition

**Results:**

- 44µm Co
- 24µm p-GaAs

**Co**

4µm lines Co on GaAs
Light-induced electrodeposition

**Principal:**

- CB (Conduction Band)
- VB (Valence Band)
- $E_{\text{redox}}$
- $E_{\text{flatband}}$

**Diagram:**

- Light excitates electrons from VB to CB
- p-type semiconductor

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$e^-$ are photo-excited from VB to CB and participate in the conduction process

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Light-induced electrodeposition

Electroless deposition of Cu occurs **only** where laser (488nm) shines on p-Si.

**Experimental:**

- LASER
- IRIS
- Beam expanding lens
- Mirror
- Mask
- Lens
- p-Si

Cu sulfate solution 0.1M pH=2.5
Light-induced electrodeposition

Results:

Cu on p-Si
Conclusion

• Selective patterned electrodeposition of Co on n-GaAs ⇒ Few microns lines
• Direct lithography through photo-electrochemical deposition of Cu on p-Si. ⇒ 20mm feature size

• Future work:
• Electrodeposition of smaller patterned metal film onto doped semiconductors (Si, GaAs)
• Photo-electrochemical deposition using small interference pattern onto doped semiconductors.