UNIVERSITÄT BONN

SI LAB Silizium Labor Bonn

FTD

Electrochemical copper deposition process

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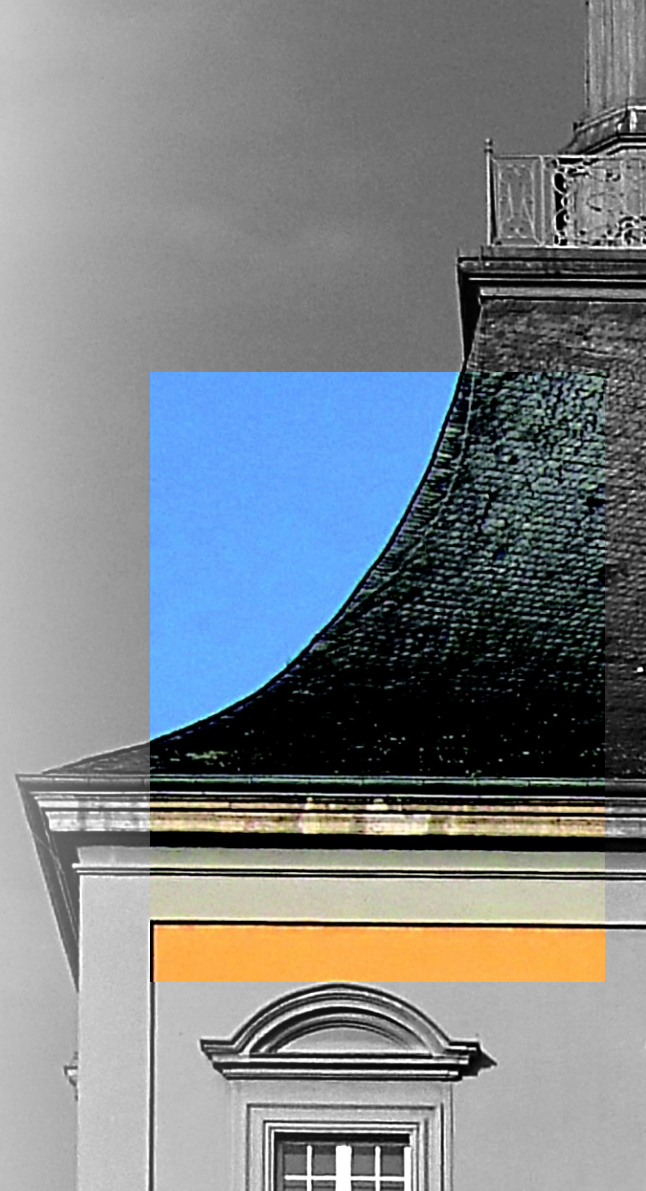
Andreas Ulm

Physikalisches Institut der Universität Bonn



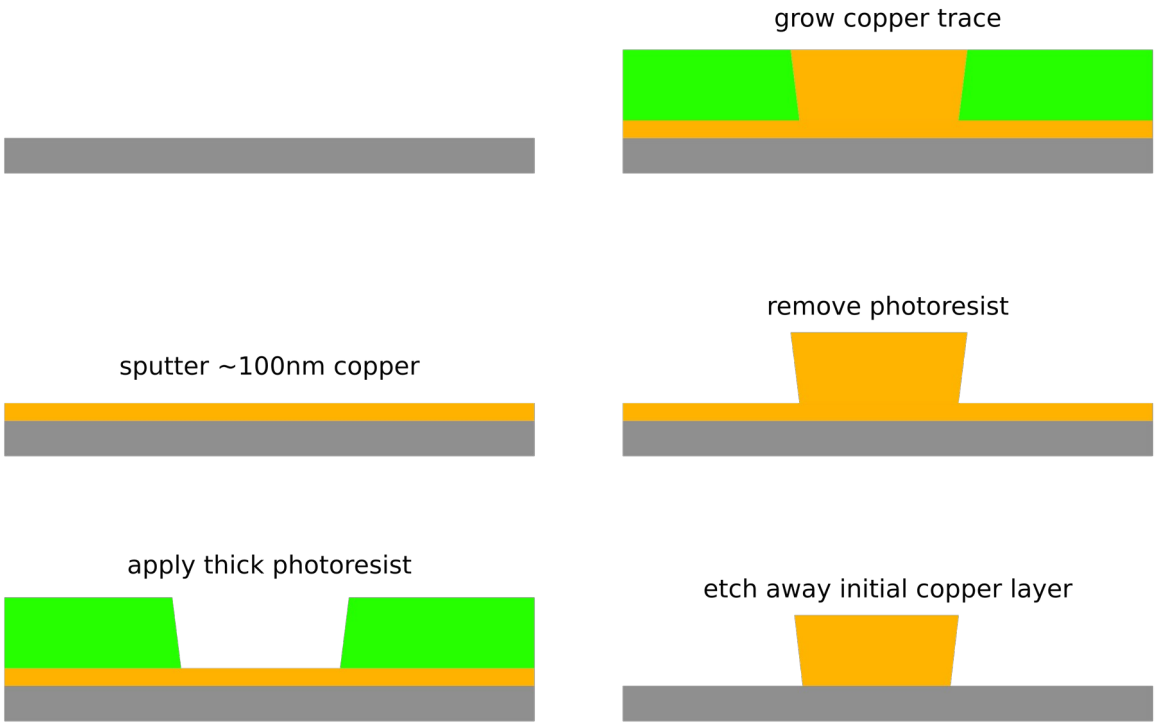
Motivation

We should get a electrochemical copper deposition process:

- Useful for thick layers of metal
- Copper has better conductivity than Al
- Less stress for metalization process
- Used for All-Silicon Modules as IZM does not have thick Al process
  - Useful to have comparable process to create test structures to characterize technology
  - Much, much cheaper to build structures by ourselves
- Useful for future projects that absolutely need copper
- First step for Through Silicon Vias (TSV)

Copper trace process:

- Deposit thin layer (seed layer of ~100nm) of copper on substrate
- Apply thick photoresist (at least in thickness of trace) on copper layer
- Grow copper trace electro chemically in structured photoresist
- Remove photoresist
- Etch away seed layer thickness



Electrochemical deposition (ECD)

- Non-toxic **copper sulfate** bath for deposition
- Copper sulfate + sulfuric acid forming ionized species in solution
  - Solution is highly conductive
  - Sulfuric acid can attack sputtered metals
    $(2Al + 3(H_2SO_4) \rightarrow Al_2(SO_4)_3 + 3H_2$
    - Investigation of effect necessary! Possibly other seed metals necessary (chromium, copper)
- Current density of 215 – 1075 A/m^2
  - Lower currents can cause copper sulfate build up
  - High currents can destroy copper anode → rough deposit
- Electrode efficiencies should be close to 100% (need investigation if Al cathode is usable)
- Electrolysis reaction:
  - Cathode reaction: Cu2+(aq) + 2e- → Cu(s)
  - Anode reaction: 2H2O(l) → O2(g) + 4H+(aq) + 4e-

What needs to be investigated

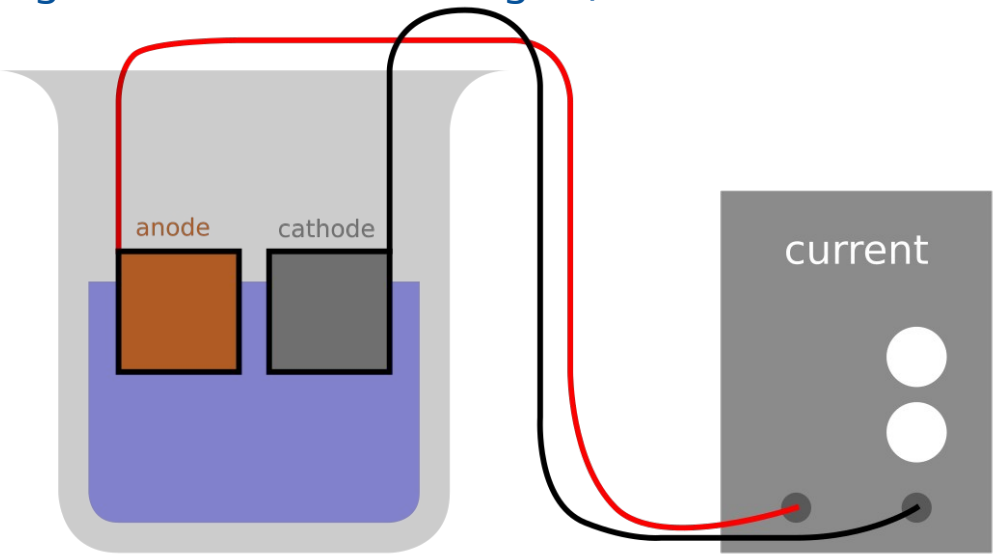
- Can we grow copper on aluminum (or do we need a different target like copper or chromium)

- Adhesion on wafer/aluminum/photoresist
- Copper growth rate
- Copper growth uniformity

- Investigate dependence of
  - Pretreatment of aluminum electrode
  - Current
  - Concentration of solution
  - Initial layer thickness
  - Pulse current deposition
  - Other possible parameters

Where to start

- Sputter 2cm x 2cm chips with 100nm Al (also good test for new Al targets)
- Build small ECD setup in ISO5 wetbench
  - Lab PSU
  - Glasware
  - Copper Anode
  - Cables
  - Cathode holder
  - Stirrer
  - Copper sulfate solution



- Investigate deposition properties for pure Copper sulfate solution first (expecting ~10mA)
- Add Sulfuric Acid to solution (mix new solution) and investigate metalization process (expecting ~100mA)

Outlook

- Once process was initially tested, try improvements:
  - Development of procedures
  - Variation of additives (Chloride, Thiourea, wetting agent, Dextrin, Molasses)
  - Improve setup mechanically
- Try premixed solutions for commercial use

- Once process is established:
  - Investigate TSV capabilities (Maybe with BASF solution or self mixed solution)