Nanowire-assisted Micro Loop Heat Pipe with Porous Silicon Wicks

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Research Goals

- **Background**: Thermal management of high power density electronics is an essential issue for next generation of computer, integrated circuit and military systems.

- **Objective**: To develop and demonstrate the requisite technology for a planar thermal ground and nanowire assisted micro loop heat pipe.

- **Key Components**
  - Porous silicon wick – to feed water from reservoir to the evaporator surface.
  - Zinc oxide nanowire – to pull water up from inside the silicon pores.

Fabrication Process

1. Porous Silicon Wick

   - **Thermal CVD furnace**
   - **Silicon and silicon carbide (3C-SiC)** substrate coated with 1.5 nm Au catalyst
   - **Ceramic** boat packed with 1:1 mixture of ZnO (99.999%, metals basis) and graphite (99%, crystalline) powder
   - Argon and oxygen gas at 25 and 0.5 SCCM, respectively
   - 900 °C for 10 minutes

   **Fabrication Process**
   - **Metal-assisted etching**
   - **Electrochemical etching**
   - **Backside etching**
   - **SiO₂ patterning and isotropic wet etching**
   - **Release etching**

2. ZnO Nanowires (VLS, Vapor-Liquid-Solid)

   - **SiC substrate**
   - **Metal Deposition** (500 ml 49% H₂ + AgNO₃, for 2 min)
   - **Branched Silver Dendrites**
   - **Metal assisted chemical etching**
   - **Electrochemical etching**
   - **Ag particle**

   **Nanostructure**

Results

1. Porous Silicon Wick

   - **Electrochemical etching**

2. ZnO Nanowires

   - **Si substrate**
   - **3C-SiC substrate**

   - **Metal deposition** (500 ml 49% H₂ + AgNO₃, for 2 min)
   - **Branched Silver Dendrites**

   **Nanostructure**

Conclusion & Future Works

**Summary**
- The planar thermal ground and nanowire-assisted micro loop heat pipe has been proposed for the next generation cooling system.
- Two key components (i.e. porous silicon wick and ZnO nanowires) have been fabricated and synthesized to circulate and transport the working fluids efficiently.
- Two fabrication techniques (i.e. the electrochemical and metal-assisted chemical etching) for porous silicon wick has been introduced.
- The bottom-up synthesis (VLS) for ZnO nanowires has been demonstrated on both Si and SiC substrate.

**Future Works**
- Anodic bonding between three layers and hermetic sealing for packaging.
- Measurement for the mass flow rate of working fluid and numerical calculation for the analysis of heat transfer and thermal efficiency.