Design of a MEMS Non-Magnetic Heater

Non-magnetic heaters are desirable for systems that are sensitive to magnetic fields, such as micromachined gyroscopes using spin-polarized nuclei. The project aims to design a heater based on transparent resistive heaters on a glass substrate to generate heat while generating minimum magnetic field. The design concept is based on the cancellation of magnetic field by currents flowing in opposite directions. Double-layer and coiled structures are the potential geometrical configurations that may provide the cancellation mechanism. The heater will be fabricated by using indium-tin-oxide (ITO) which is optically transparent as one of the requirements of the gyroscope. The heater thickness is the same throughout the heater and the micromachining process limits the minimum width of the structure.

Part A
The following parameters are fixed and not adjustable for you:
- Minimum width of the heater structure \( \geq 2 \, \mu m \)
- Minimum gap \( \geq 2 \, \mu m \)
- Thickness of the device \( \leq 5 \, \mu m \) & \( \geq 0.2 \, \mu m \)
- Device (heater) Area = 1mm x 1mm
- Resistivity of ITO = 3e-4 \( \Omega \)cm

The following are the engineering goals you must meet:
- Minimum power generation: 50mW
- Maximum DC input voltage: 10Volts
- Maximum magnetic field 0.5mm above the heater: 10^{-6} Gauss

Please complete the design by constructing the structure (including input and output contacts) so that your design meets all the constraints and goals. If you can’t meet all the constraints and goals, then attempt to meet them as much as possible and explain why you feel your choice of parameters is the best. For the report, please follow the format given on the website and be sure to explicitly state the values of:
1. All chosen geometry and dimensions for your design.
2. Actual values achieved for all engineering goals
3. Magnitude and location of maximum magnetic field in the design
4. If you cannot find a solution under these constraints, what are the things you would change in order to meet most of the requirements?
In the theory section of the report, please be sure to clearly state your decision logic in choosing the values of the dimensions you select. “I just made guesses,” “I gave up after 2 hours of trying” or similar characterizations are not acceptable statements of the decision logic. You can use Matlab or other environment to do the computations and use the FEM analysis to verify your design results. You may need to use COMSOL for the project.

![Figure 1](image)

**Figure 1**, A design (fabricated) example showing the heater design and temperature sensor (temperature sensor is not needed in your design).

---

**Part B**

It was assumed that there is no heat lost via substrate and wires in part A of the project. Furthermore, a power generation requirement is given without getting to the real requirement. You will get your full credit by working on Part A only. You are welcome to work on one or several of Part B only if you have finished Part A and would like to get extra challenge and credits. This part of the project considers several issues that were neglected in Part A of the project.

1. we would like to generate a temperature of 90°C on the substrate.
2. the substrate (glass) and contact wires (gold of 25μm in diameter) will conduct heat.
3. It is also desirable to be able to conduct feedback control to have the 1°C resolution and temperature sensing is one possible way for this. However, this will require putting a temperature sensor (as shown in Figure 1 in the design). Please address these issues as best as you can.