25 March 2025 ·
Qeios

Peer Review

Review of: "Angular-Controlled GST Phase-Change Double Micro-Ring Resonator for High-Speed Activation Functions in Neuromorphic Computing"

Roseanna Lawandi[1]

1. University of Dayton, United States

In this paper, the authors discuss the use of GST in double micro-ring resonators to achieve high-speed neuromorphic computing functions.

To date, I haven't seen a double micro-ring resonator architecture incorporating GST, making their work novel in that sense. They also identified the angular positioning of the PCM in order to achieve narrowband transmission with high modulation coefficients, which is also novel. However, unfortunately, the authors lack information on experimental methods and material characteristics, making the paper weak in its current form.

Kindly note the improvements I believe are significant in making the paper publishable:

- The introduction was repetitive and very dispersed. Please proofread to clean up the repetition. As for the dispersed information, contain your literature reviews to a few paragraphs. It is critical to show readers the current advancements in the field and how your work would be beneficial. However, talking in depth about things not directly related to your work distracts the reader and diverts attention from your work.
- Theoretically, the results look good. However, practically, and given the described "Fabrication Process," this device can't be fabricated. In other words, here are a few items to consider:
  - SiO2 substrates are not feasible to be used in modern technologies that rely heavily on fabrication on Si wafers. Consider a thick SiO2 film on a Si wafer as an alternative.
  - The use of UV light for patterning has feature dimension limitations due to light wavelength and diffraction. Reconsider the patterning process given the features discussed for this device.

 doi.org/10.32388/VNYHDW

- Lift-off of Si is unprecedented, especially in photonic integrated devices like ring resonators, due to the necessary Si sidewall desired for light confinement. Unless a strong reference is provided on how this will be implemented, it is unacceptable.
- Thermal evaporation does not provide compact thin films. This poses complications such as air pockets within the etched Si that's to be filled with GST and/or pinholes within the GST thin film itself.

- Reversibility is not mentioned in this work. GST is a non-volatile PCM, and if the authors are implying that the GST can switch between the different phases (0-350°C) as per Figure 7, then this work is scientifically incorrect. If so, kindly familiarize yourself with GST by reading about experimentally switched films (there are many publications showing thermal, optical, and electrical switching of the film and reversibility limitations).
- GST embedded within Si resonators is novel. However, practically, fabricating such a device is not easy, and there are many limitations to name a couple: sidewall features of the etched Si resonator and GST filling the etched gap fully (i.e., without air pockets).
- The potential of GST oxidation and thermal dissipation are not discussed. These are critical limitations when implementing GST in any device. Please either tackle them by adjusting the device design or mention the limitation and possible failure modes.
- The choice of GST as the PCM was not explained. Why were other less lossy materials not chosen?
- Using a 100nm SiO2 substrate is not possible. Typically, one can consider SiO2 as a "substrate" when a Si wafer with a thick SiO2 is used. I would recommend the simulation to either consider a thick SiO2 layer (ex: 500nm) or use a Si substrate and observe if that affects any results. This would make the paper comprehensive both theoretically and practically.
- The "optimized thermal management approach" and "efficient thermal switching" mentioned in the paper need to be described better, as I am not sure what the authors are referring to.
- 100°C GST is still not in the crystalline state. I understand that the experiments show that 100°C GST is showing the best simulation results. Material-wise (i.e., practically), what phase is the GST? Is the assumption that the GST is not amorphous at this temperature? If so, a strong reference needs to be provided to support the claim.
- Housekeeping notes:
  - When adding a reference, number them in the order they appear. For example, instead of saying "[43][28][2][14]," say "[2][14][28][43]."

- For Figures: **4a)** I would swap the marker shape so that the green overlaps the red for better visual clarity. **4b)** Phase 7 is not clearly showing that FHWM 1 and 2 are overlapping; I would recommend using different markers. **7)** This is very misleading since it is presenting GST as a volatile PCM (This is scientifically incorrect. GST is a non-volatile PCM.). If the authors believe this claim is true, it needs to be backed up with a strong reference. **S3)** I would include the data for W2=410 for a complete graph (i.e., better visual clarity).
- Why was Phase 9 not an option (i.e., it was left out of the short list)? It seems fairly within the "acceptable phases" mentioned. Reconsider the list or clarify better why a phase like Phase 9 is not included.
- Supplementary Document S4 is not well written. Rather than typing out the information from the table and graphs, I would recommend highlighting and summarizing what is significant from the data collected. Readers can look for specific numbers for each width if needed by looking through the presented table.

I recommend major modifications before considering re-submission. The paper in its current form is not acceptable for publication. The novelty mentioned above, though, is worth publishing, so I highly recommend that the authors perform the scientifically correct modifications necessary and re-submit.

Declarations

Potential competing interests: No potential competing interests to declare.

doi.org/10.32388/VNYHDW