

Dear Editor of the Review of Scientific Instruments,

On behalf of our research team at the Institute for Quantum Computing, University of Waterloo (PI: Prof. Rajibul Islam), I am delighted to submit our manuscript titled "Fast and high-yield fabrication of axially symmetric ion-trap needle electrodes via two step electrochemical etching" to your prestigious journal. I hope you will consider this article for peer review.

Ion traps are a leading technology for quantum information processing (QIP) and atomic clocks. Many ion traps, such as our four-rod Paul trap – a workhorse in many laboratories, use electrodes that are shaped like needles. In this manuscript, we report our recipe for fast and reliable fabrication of such needle electrodes using electrochemical etching. We invented this recipe after wasting a few months following the only documented previous literature [1] that resulted in an extremely low yield of electrodes suitable for a capable QIP research apparatus. Our recipe uses a much simpler setup than in the previous ion trap literature or the related field of STM-tip fabrication and produces 100% yield of usable electrodes. We fabricated all needle electrodes for our trap in a day. We expect that this manuscript will be a 'go to' reference for new ion trap laboratories.

The novelty of our work is to make use of the previously unexplored turbulent regime of electrochemical etching. While conventional wisdom in etching is to stay away from turbulence, we found that this regime significantly speeds up the process reducing finer alignment requirements of electrode fabrication. The loss of surface quality from the turbulence can then be cleaned up in a subsequent polishing process.

Your journal published research in both etching techniques [2] and instrumentation for ion traps [3]. Thus, we are hopeful that you will find our manuscript to be suitable.

Sincerely,

Nikhil Kotibhaskar

PhD Student

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## References

[1] Wang, Z., Luo, L., Thadasina, K. et al. Fabrication of ion-trap electrodes by self-terminated electrochemical etching. EPJ Techn Instrum 3, 3 (2016). <https://doi.org/10.1140/epjti/s40485-016-0030-5>

[2] Bing-Feng Ju, Yuan-Liu Chen, and Yaozheng Ge , "The art of electrochemical etching for preparing tungsten probes with controllable tip profile and characteristic parameters", Review of Scientific Instruments 82, 013707 (2011) <https://doi.org/10.1063/1.3529880>

[3] T. G. Ballance, J. F. Goodwin, B. Nichol, L. J. Stephenson, C. J. Ballance, and D. M. Lucas, "A short response time atomic source for trapped ion experiments", Review of Scientific Instruments 89, 053102 (2018) <https://doi.org/10.1063/1.5025713>

