Dear Editor of the Review of Scientific Instruments,

We thank you for sending our manuscript titled “Fast and high-yield fabrication of axially symmetric ion-trap needle electrodes via two step electrochemical etching” out for review. We appreciate the second reviewer’s favorable opinions. We understand that your decision to reject our manuscript for publication is primarily based on Reviewer #1’s concerns. However, we strongly disagree with Reviewer #1’s assessment of our work and we would like to appeal against this decision.

Reviewer #1 agrees that “the paper is fairly well written, and the results described therein do support the claim of the paper”. The reviewer’s main issue with the manuscript seems to be the subject itself. Their main arguments are – “Many labs, mine included, have devised their ways of fabricating these needle electrodes” and “For a regular research lab, neither high speed nor high yield are important”. We disagree with both these arguments. We decided to document our novel way to fabricate electrodes from a strong conviction that peer-reviewed and well documented technical steps push the field forward. Why must every lab invest valuable resources to find ‘their ways’ to reinvent techniques? For the specific example of ion trap needle electrodes, we found only a single peer-reviewed publication [1] explaining the use of electrochemical etching for this purpose. Unfortunately, the documented recipe is technically complicated and results in low yield. While the reviewer is correct that typical ion trap labs need a few such electrodes, we found following the reference cited above, that fabricating a highly symmetrical pair of matching electrodes took many trial runs and indeed we ‘wasted’ almost two months in the process. Our recipe results in deterministic preparation of electrodes and a symmetrical pair can be prepared in a day. We appreciate reviewer #2’s comment offering a broader perspective - “this method could also be applied in other fields which needs similar needles”.

Reviewer #1 did not provide us with a peer-reviewed reference with which we can compare with our work, further pointing to the need for such published work. We analyze the profile of our electrodes quantitatively in our manuscript and thus future work on this topic can accurately compare results. Laboratories with different requirements from their needle (size, taper etc.), can optimize their fabrication parameters as explained in our manuscript.

Please see below for other comments of the reviewer:

1) "One of the simplest geometries to trap ions, a four-rod Paul trap, employs sharp needles to create confinement" (2nd sentence in the 1st paragraph) is rather confusing, since the needles are only used for the axial confinement, which is a DC trap, not a Paul trap.:
   We agree! We can change this to: “One of the simplest geometries to trap ions, a four-rod Paul trap, employs sharp needles to create axial confinement” The addition of the word axial should remove the confusion.
2) "The surface quality and symmetry of the electrodes determine the usability of such a platform by affecting the ion heating rate" (the following sentence; also repeated in the middle of the 2nd paragraph) is also rather misleading since the needle electrode surfaces are typically much farther away from the ions than the surfaces of the trap rods, so the quality and the cleanliness of the rods is more important to the heating rates.”
   Point noted! We can change the sentence to the sentence below:
   “The surface quality and symmetry of the electrodes, both rods and needles, determine the usability of such a platform by affecting the ion heating rate”
   Though we agree that most labs have needles farther from the ions compared to the rods,

there is great interest in traps where needles are closer than the rods. Phil Richerme's trap [2] for creating a 2D crystal comes to mind. Hence, we want to stress the importance of both the rods and the needles through this new line.

3) "We use a 3" cylindrical shield..." at the beginning of Section III.A - it would be better to use SI units.
   We agree!
4) It sounds like the resultant needle diameter is less than the wire stock it starts out as, this seems somewhat like a drawback. In other fabrication techniques, including the one we use in our lab, the non-tapered part of the needle has the same diameter as the original wire.
   This statement is not supported by the underlying physics of electrochemical etching. As explained in Sec II of the current manuscript, electrochemical etching etches away material from the whole electrode and hence there is a reduction in the diameter of the non-tapered end. Zhang et al [1] used an insulating cylindrical tube around the non-tapered end to mitigate this effect but this makes the fabrication apparatus complex. We circumvent this problem by simply starting with larger diameter rods (Tungsten welding electrodes are cheap and come in a variety of sizes).
5) It's a very bold claim to call this a "novel technique".
   We stand by our claim of novelty. The high yield rate of symmetrical electrodes arises from our use of the breakdown/turbulent regime of electrochemical etching. We are unaware of this approach being used before - from literature, folklore in the ion trapping community, or popular wisdom of electrochemical etching. The previous documented work, Zhang et al [1] said the following about this regime:
   "Finally, at the high voltage side of Zone IV , the electrolyte solution begins to decompose and turbulence develops in the solution, where the etching process becomes uncontrollable."
   Despite this we explored the regime and found that the benefits significantly outweigh the costs.
   Apart from this, our recipe uses an unconventional mechanical scheme during etching – against the recommendation of the previously documented recipe. We quote:
   "For translating the rod during the etching process, it is required to pull the tungsten rod up instead of pushing-down because pushing-down will result in the multi-level etching on the down-piece. By pulling up, the multi-level structure only appears on the up-piece"
   We show in our manuscript that employing the exact opposite approach and intermittent driving of the needle (drastic simplification) makes the process fast, efficient and repeatable.
6) It does seem like an improvement of an old and tested technique.
   It is a significant improvement in our ability to make symmetric needle electrodes. We have simplified the technique and the apparatus, drastically improved the repeatability and provide clear explanation for tweaking process parameters for varying the needle shape. In our manuscript we also provide detailed test of the replicability of our recipe and characterization of the needle shapes unlike the previous published work.

Apart from the above clarifications, we would also like to draw parallels between two similar publications, which share the same philosophy.

Ever since RF traps were invented, ion trappers have been using the classic reference from Macalpine [3] (published in 1959!) for designing their trap resonators. Each trap needs only one RF resonator to function and hence every group figured out their own way to build these. But as the field progressed, the time devoted to fabrication of the resonator was at best a distraction for the researcher interested in the physics of the ions and not resonator fabrication. J.D Sivern's work [4], published in 2011, provided a clear and repeatable technique and is now the go-to resonator paper for the ion trapping community. In fact, subsequently there were more results published, documenting further improvements in the technique see for example K. Deng et al [6].

In similar light, ion trappers have been designing atomic ovens which emit the atoms that are trapped. Many ion-trapping groups, including ours, have been coming up with their ways to build atomic ovens with fast response times. However, a documented technique for building a fast-acting atomic oven, with detailed characterization, had been published in RSI as late as 2018 [5] and is now an important peer reviewed literature in the field.

We hope that we were able to argue the need for a peer reviewed well documented and characterized recipe for instrument building. We believe that our manuscript will serve as an important reference for future labs. We therefore request you to reconsider your decision and if needed, please seek additional consideration from more reviewers.

Sincerely,
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References:
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[5] 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

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