**Editorial comments:**  
The manuscript has been modified by the Science Editor to comply with the JoVE formatting standard. Please maintain the current formatting throughout the manuscript. The updated manuscript (55257\_R0\_072616.docx) is located in your Editorial Manager account. In the revised PDF submission, there is a hyperlink for downloading the .docx file. Please download the .docx file and use this updated version for any future revisions.  
  
Changes to be made by the Author(s):  
  
1. Please take this opportunity to thoroughly proofread the manuscript to ensure that there are no spelling or grammar issues. The JoVE editor will not copy-edit your manuscript and any errors in the submitted revision may be present in the published version.  
Spelling and grammar issues have been addressed.

2. Please abbreviate all journal titles.

Completed.  
  
3. Please define all abbreviations before use.

Completed.  
  
4. All tables should be uploaded separately to your Editorial Manager account in the form of an .xls or .xlsx file.

Completed.

5. Please provide titles for each Figure.

Completed.  
  
6. Formatting:  
-Please convert Table 1 to an Excel file. The .png cannot be used, and looks to have been obtained from a manual.

The table has been converted into an excel file. The .png was obtained from a prior document that the authors had written for Nufern.

-3.5.10 – The wrong steps are cited here. Please correct them.

Steps have been corrected.

-Please define all abbreviations at first occurrence (ie TEC, TM, TE, etc.).

Completed.

-The reference 9 citation is incomplete.

Reference 9 has been completed.  
  
7. Please copyedit the manuscript for numerous grammatical errors, some of which are listed below. Such editing is required prior to acceptance.  
-Line 71 – “One…are…”  
-1.4.3 – “my” typo  
-1.4.4 – “is indicates”  
-3.4 – “3-axis stages” – are these multiple stages?  
-3.5.2 – “core…are”  
-Table 1 should be titled “Settings for…” rather than “Recipe”.

These editing fixes have been noted and fixed in the manuscript.  
  
8. Additional detail is required:  
-1.3 – How is cooling controlled?

Now addressed in text of 1.3.

-1.4.3 – How are these adjustments made?

Now addressed in 1.4.3 and 1.4.4.

-2.3 – Cleave how and by how much?

Now addressed in 2.3. Length will be set by the commercial cleaver of one’s choosing.

-3.1 – What is a TEC?

Now addressed in 3.1, thermo-electric cooler (TEC).

-3.4 – Are the fibers mounted to the stage or is the chip? How? How many fibers are used?

Which are input and which are output?

Now addressed in 3.4. and 3.5.

-3.5.5 – What ring?

Now addressed in 3.5.6. Ring refers to the micro-ring resonator.

-3.5.6 – When were fibers attached to the power meters?

Now addressed in 3.5.1.

-4.4 – Please provide a citation. It there is insufficient detail.

Additional details were added in section 3.7.

How is this done?  
-4.6, Now addressed in 3.8.

4.9, Now addressed in 3.11 and 3.12

4.10 Now addressed 3.13 and 3.14.

9. Please remove commercial branding: Table 1 – Fujikura

Completed.  
  
10. Results: Figure 3 – Please describe each of the plots individually. What are their differences?

Completed, differences were the choices of pump wavelengths used to generate the bi-photons.  
  
11. Discussion: Please discuss the future applications of the protocol.

Added a discussion section for future applications.

**Reviewers' comments:**  
**Reviewer #1:**  
*Manuscript Summary:*  
The manuscript describes the measurement of quantum interference in an integrated silicon device, where both source (four wave mixing parametric downconversion) and interferometer (an inscribed MachZender interferometer) are monolithically fabricated on a Silicon chip.  
Authors describe in details the polishing phase, and the coupling in and out to a fiber, as well as the optical configuration used to measure the interference. They finally show figures clearly displaying quantum interference, featuring a period double the classical fringes, indication of the generation of NOON state photon at the source.  
  
*Major Concerns:*  
My major issue with the manuscript is the inconsistency between the title and the technique presented. Indeed the authors present an quantum interference measurement, but the larger part of the methods focuses on the chip preparation and optical coupling, that is more of a general issue.

The manuscript has been modified to more closely reflect the title.

The authors should address better the steps that are more related to the experiment (or in general for performing quantum optics on Si devices), i.e. part 4 should be extended. Here are few technical issue that could be addressed  
- Indicate the pump power levels, state if amplification is needed, and if care has be taken to tune the laser into resonance (e.g. if thermal shift plays a role)  
- Stress the importance of noise and pump filtering and how to achieve 120 db noise suppression.  
- Indicate other possible sources of noise (i.e. multi-pairs generation or stray light from the top of the chip)  
- Show the photon-pair temporal characterization and how you determine the gating window  
- Since the platform is Si, a comment on the 2-photon absorption should be given, including way to manage it via PN junction

Sections 3 and 4 of the manuscript have been extended with a more in depth discussions of these issues to address all of the above points.   
  
*Minor Concerns:*  
I believe the discussion of losses and taper coupling is a little confusing: the inverse taper is not well described in the text, especially in relation with the polishing. Maybe a figure/close up could clear the explanation.

A clearer description of the taper is now added to the discussion section of the paper. This section details the purpose of the taper on both sides, in fiber and on the chip. The tapering of the waveguide itself is slow enough over a long enough distance that an image would not capture the taper.

Also, little details on the photonics structure are given: what are the property of the source (Q-factor, free spectral range..) and of the interferometer (arms length, dphi/dt). What are the figure of merits that are optimized when designing the structure?

These quantities have been added to the section 3.7.3, 3.7.4, 3.13. The figures of merit are the loss, Q, FSR, and dispersion of the device to be constructed and are addressed in the note section at the beginning of the protocol section.   
  
*Additional Comments to Authors:*  
The work is well described, with clean results. It just need to be more on focused on the integrated quantum optics aspect of the experiment.  
  
  
**Reviewer #2:**  
*Manuscript Summary:*  
Firstly this is probably not the part of the experiment that needs a tutorial. The procedure of measuring entanglement, data processing, correcting for accidentals and dark counts etc. would be much more useful (especially since there is a lot of mis-understanding in that area from non-experts). That is what the title seems to suggest. But the "protocol" details are about polishing chips and basics of coupling light to them - something that is pretty simple for even a one-hour undergraduate lab. Does this really need to be in a paper?

Section 4 and the discussion have been expanded to include more of the measurement analysis of the quantum state. The polishing and setup for the experiment are just as crucial though to the experiment as they add to the loss of the entire circuit. This loss is squared when measuring coincidence, so a minimization in the loss is crucial.

Even in that area, there are too many unanswered questions to create a reliable "recipe" ...  
"place a small amount of wax on a polishing mount": what is a "small amount"? What is a "polishing mount"? Was it provided by the equipment manufacturer or made? How smooth, what material, what hardness, what thermal properties etc. ? These details are crucial for polishing (as any packaging researcher will always point out).  
"so that the chip will be firmly attached to the mount": what is "firmly"? How much force? How is it handled / attached without damaging the surface or the edges?  
"do not cool the mount too quickly": how quickly is "too quickly"?  
"Correct for any misalignment my making adjustments to the micrometers on the polisher." How is a misalignment noticed - visually, or measuring microscope or interferometer? Is there a recipe / procedure for the tip-tilt adjustment, or just trial and error? How good an accuracy can be achieved?  
"to ensure a smooth facet." What is a "smooth facet" - how smooth? How is that quantified - how does the experimentalist know when to stop?

These points have now been addressed in an expansion of section one and figure 2 which shows the unpolished and polished chip facet.

"Choose the wavelengths for the two pump lasers. They must coincide with resonances in the spectrum and ..."

This is addressed in section 3.7.5 to 3.7.9.

Much harder than it seems, because of light-induced heating and thermal resonance shifts. "soft-locking" from the red side of the deformed resonance, etc. Moreover, silicon is an indirect band-gap semiconductor, which generates free carriers ...

These are valid points and have been addressed in 4.2.

There are many more unanswered questions … I am afraid that the amount of provided information is simply not enough for a non-expert researcher to learn how to do this experiment accurately, efficiently and correctly. And the experts do not need this.

These comments have now been addressed with the expansion of sections 3 and 4.

Section 3 is far too simple. It says nothing about all the challenges in ensuring the light remains in the correct polarization state, in quantifying the amount of scattered light, in explaining the various artifacts in the transmission spectra etc.

Section 3 of the manuscript has been significantly expanded to include details addressing these issues.

Polarization state in sections 3.6, and 3.7.1

Scattered light in note immediately after section 3.5.11

Artifacts in the transmission spectrum in section 3.7.2  
  
*Major Concerns:*  
N/A  
  
*Minor Concerns:*  
N/A  
  
*Additional Comments to Authors:*  
N/A  
  
  
**Reviewer #3:**  
*Manuscript Summary:*  
The authors describe a method for the preparation of a silicon quantum photonic chip and the experimental set-up for on-chip photon state generation and quantum interferometric measurements. In this work they present the experimental set-up and the data shown in their previous work from 2015 (PHYSICAL REVIEW APPLIED 4, 021001), adding some of the experimental details and methods not presented in that article.  
In this new work submitted to JoVE they focus more on the preparation of the sample for the minimisation of losses, one of the most important aspects in this kind of experiment.  
  
*Major Concerns:*  
No Major concerns, except maybe to modify slightly the abstract.

Completed. Abstract has been slightly modified as well as additions to sections 3 and 4 of the manuscript.

They actually describe only some of the key aspects of such preparation, focusing mainly on the minimization of losses for a particular kind of device. Furthermore loss is probably one of the fundamental problems in this kind of experiment but there are also other that could limit the feasibility.

These points are now addressed in the discussion section.

Nonetheless the information on this work are useful and should be published on JoVE.  
  
*Minor Concerns:*  
1. More informations on the silicon photonic device fabrication would be beneficial (e.g. size of the waveguide, is it a strip waveguide? What kind of tapers? was it fabricated with UV lithography or e-beam lithography? depth of the substrate and so on). I request this since some of the steps described by the authors will depend on the particular fabrication used.

This is now addressed in the note at the beginning of the protocol section.

2. In point 1.7 of the protocol the authors describe the use of acetone, isopropanol and water, for cleaning residual wax from the chip. This is ok in their case but in some silicon photonic devices the in/out tapers can be fabricated using polymer waveguides, in these cases acetone can damage the device. Are there any alternatives to the use of wax or acetone?

The chips can be mounted with epoxy, or a low stick double sided tape which would not expose the chip to the wax. This would be more friendly for devices which have polymer portions. This was not explicitly addressed in the paper as polymers are not the material system that is described in this specific paper, though these are valid questions addressed by the reviewer.

3. Missing integration time information for the data plots. The reader has to search for their previous work to get this information and get the count rate observed in their experiment. It would be good to report here again this information.

This data has been added to the plots.

4. Filters information missing in table of materials, it would be beneficial to know if these are commercially available filters or specifically fabricated for this experiment

Filter information is added to the table of materials.  
  
*Additional Comments to Authors:*  
N/A