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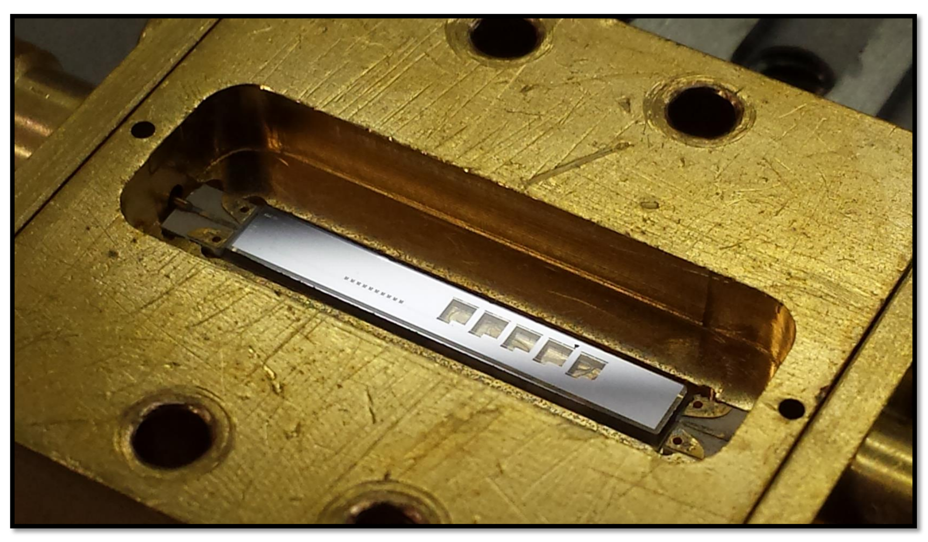
# Platinum Silicide MKIDs for UVOIR Astronomy


P. Szypryt[1], B. A. Mazin[1], B. Bumble[2], G. Ulbricht[1], and H. G. Leduc[2]

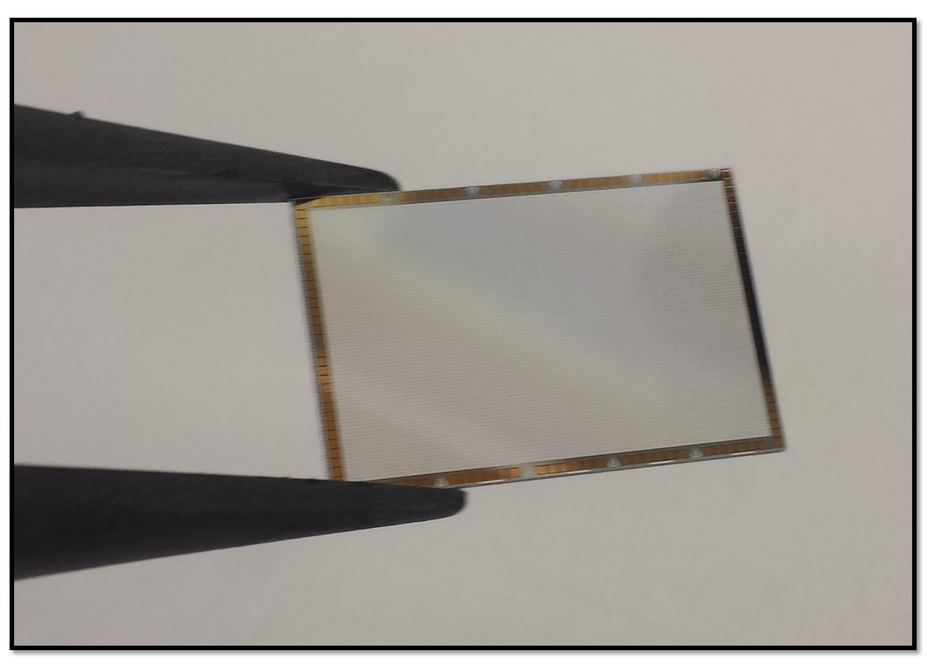
1. Department of Physics,University of California, Santa Barbara, CA 93106, USA
2. NASA Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109, USA


## MOTIVATION AND OVERVIEW

We report on the development of the first kilopixel MKID arrays using platinum silicide as the superconductor. Although PtSi is very well characterized and has a wide range of room temperature applications, the material is seldom utilized for its superconducting properties. PtSi films are easily formed through an annealing process and have tunable superconducting critical temperatures as high as 1K. Our early measurements of PtSi MKIDs show high quality factors (~150,000 or higher), energy resolution of 8 at 400nm, and quasi-particle lifetimes of ~20us. Most importantly, the PtSi films have extremely high uniformity across a wafer. Current standard sputtered TiN thin films need to be sub-stoichiometric in order to achieve the desired critical temperatures for MKID applications, but sub-stoichiometric films often have wide variations in composition, causing resonant frequencies to shift away from their designed values. These shifts can cause resonators to collide in frequency space, rendering many such resonator pairs unusable in the readout and significantly reducing the total pixel yield. We find that the PtSi fabrication process is intrinsically more uniform than the sputtered TiN process while retaining a majority of its favorable qualities. This should allow for much finer frequency-domain multiplexing and nearly perfect pixel yield, improvements necessary for next-generation MKID instruments.



PtSi Test Device

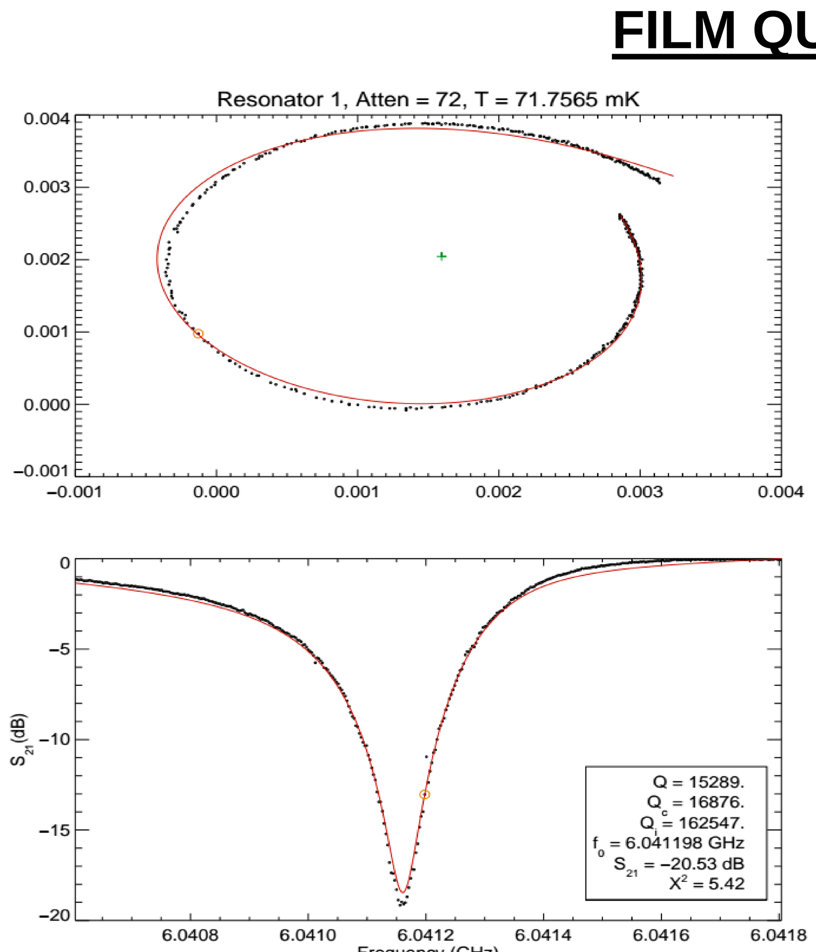


PtSi DARKNESS Device

### PtSi MKID Test Device Properties

| Critical Temperature $T_C$ | Internal Quality Factor $Q_i$ | Energy Resolution $E/\Delta E$ | Quasiparticle Lifetime $\tau_q$ | Optical Absorption |
|---|---|---|---|---|
| 850-910 mK | 150,000 | 8 | 20 $\mu$s | 20-40% |

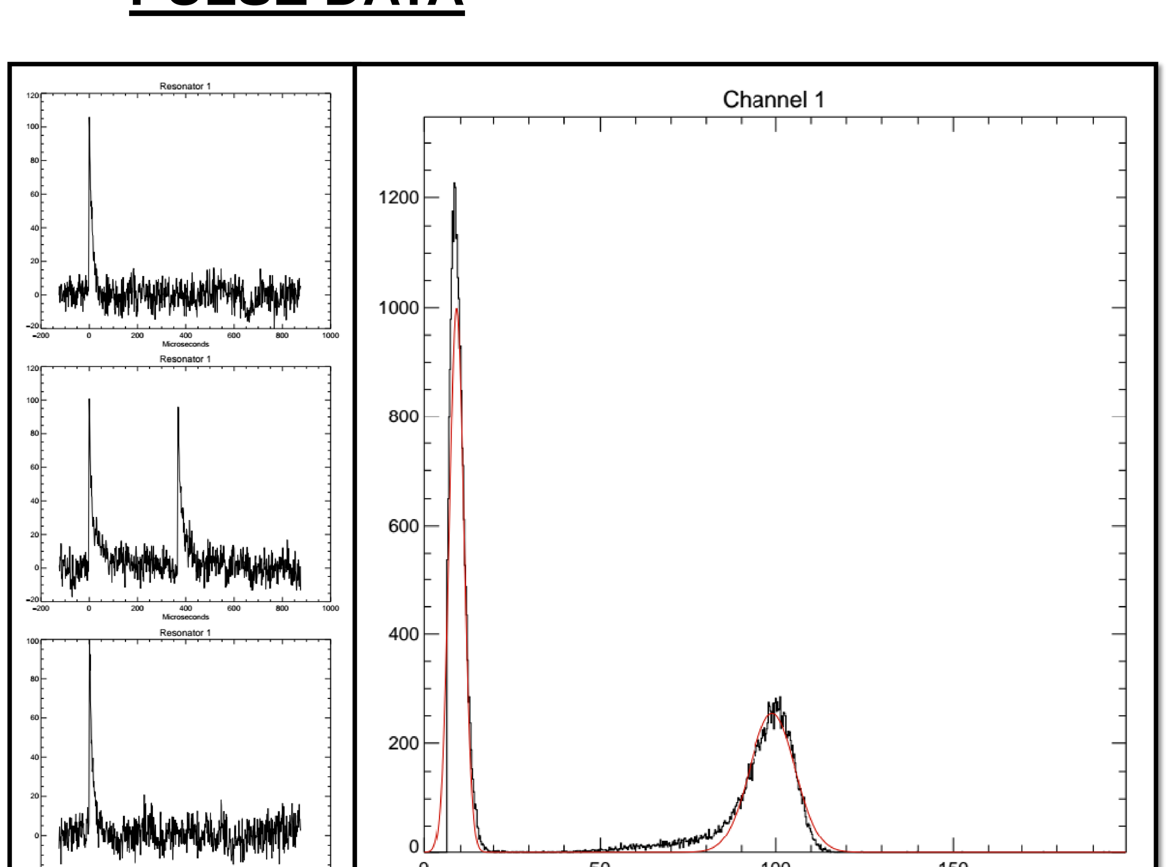
## FILM QUALITY




- Critical temperature of 850-910 mK measured by taking simultaneous DC resistance and temperature data during dilution refrigerator ramp down.
- To measure $Q_i$, probe tones are sent through the device near resonance, resulting in dips in transmission, or loops in the I-Q plane.
- I-Q loops are fit to separate out internal quality factor, $Q_i$, and coupling quality factor, $Q_c$, from the total quality factor, Q.
- Fairly high internal quality factors of ~150,000 have been measured with PtSi test devices.

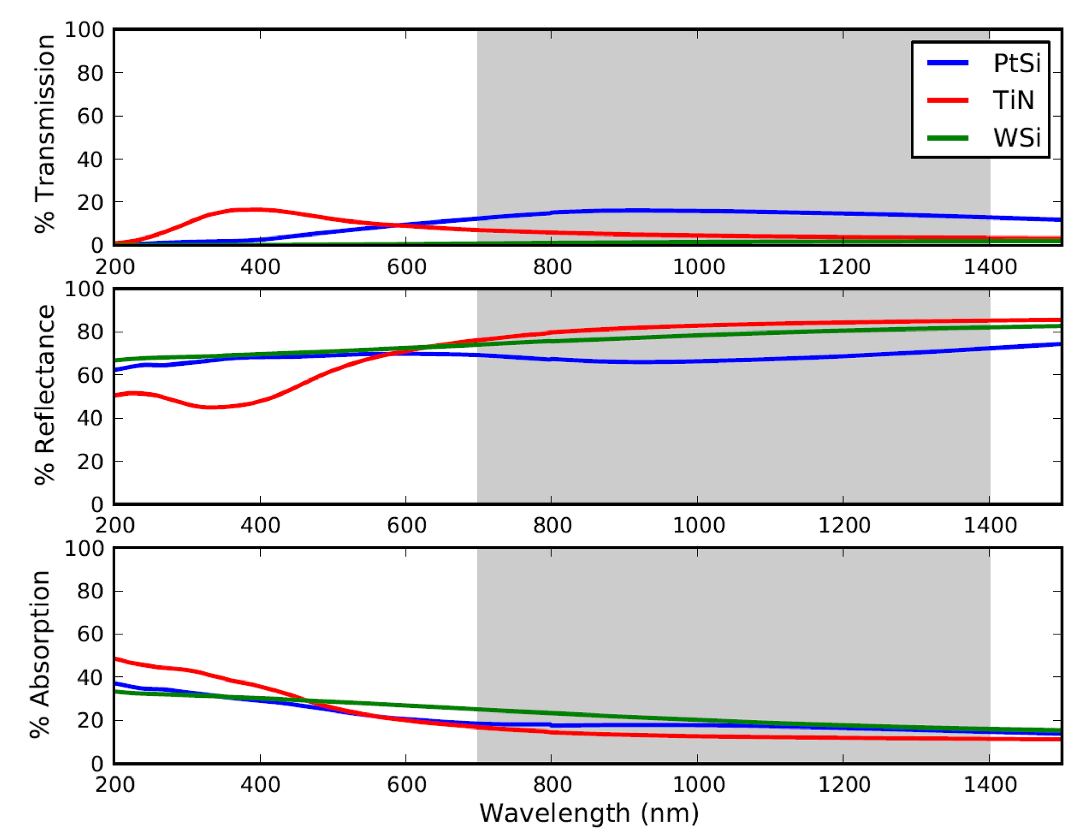
## PULSE DATA

- Photon data taken through direct optical access in ADR.
- Sample photon hits and histogram of resulting pulse heights shown on right.
- Pulse decay time measured to calculate quasiparticle lifetime of 20 $\mu$s.
- 405 nm laser source used to produce ~100 degree pulse heights.
- Pulse height histogram used to calculate energy resolution, $E/\Delta E$, of ~8.




Photon Hits    Pulse Height Histogram

## QUANTUM EFFICIENCY

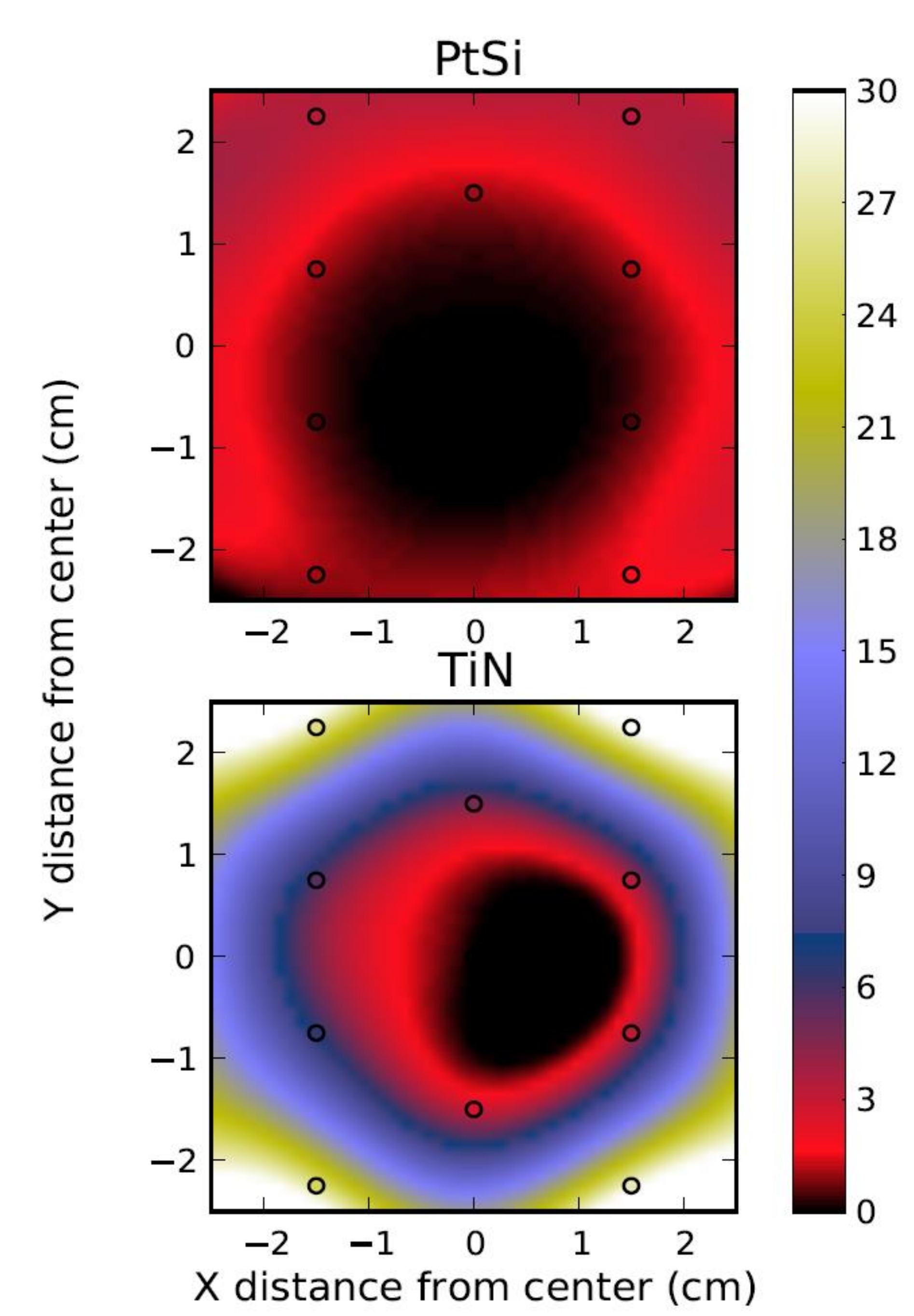



- Cary 5000 spectrophotometer used for wideband transmission and reflectance measurements.
- Thin film absorption calculated directly from spectroscopic transmission and reflectance.
- Shaded region represents the wavelength band of DARKNESS, an MKID-based planet imaging instrument currently in development.

## UNIFORMITY

% Variation in Sheet Resistance from Center

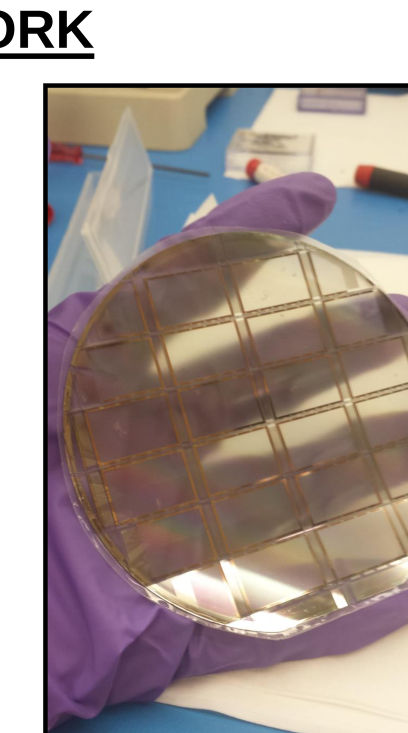
- Major problem with sub-stoichiometric TiN is non-uniformities in composition caused by insufficient control of sputter conditions in a region where the critical temperature has a high sensitivity to Ti-N ratio.
- Local non-uniformities can cause MKID resonance frequencies to shift, resulting in frequency overlaps when the pixel density is high. These particular pixels cannot be reliably read out.
- PtSi is sputtered and then annealed to it's thermally stable stoichiometry, which happens to be in the ideal temperature range for current UVOIR MKID operation.
- Early measurements of sheet resistance across 4" wafers indicate that PtSi can be more than an order of magnitude more uniform than TiN.




## SUMMARY AND FUTURE WORK

In order to increase our ability to multiplex large MKID arrays, we are replacing our sub-stoichiometric TiN resonators. At the moment, PtSi is a very promising material candidate. Early measurements have shown quality factors of over 150,000, energy resolution of about 8, and an order of magnitude more uniformity in sheet resistance across a 4" wafer. In the near future, we will be tweaking the fabrication process on sapphire and testing kilopixel PtSi arrays.

NEW AJA Sputter System arriving in September:
- UHV system with up to ~1000 times better base pressure than current system, resulting in far fewer impurities.
- Private use system – more control over sputter targets and chamber conditions.



## ACKNOWLEDGMENTS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