

Use of ^{19}F NMR Spectroscopy in Silicon Solar Cell Fabrication

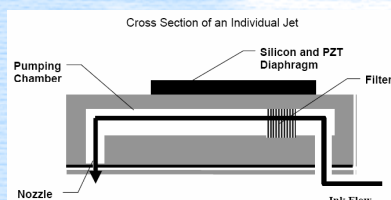
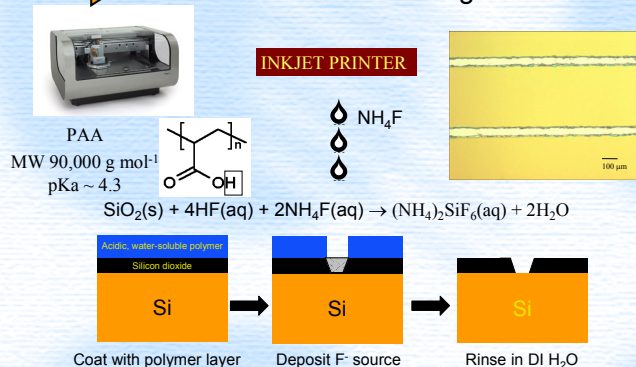
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BACKGROUND

- Efficiencies of laboratory-fabricated silicon solar cells (25%)^{1,2} exceed those of commercial cells (16-18%).
- Need to replace photolithographic dielectric patterning processes (used by the high efficiency laboratory cells) with cheaper process such as inkjet printing.

➔ Maskless Patterned Etching method.³

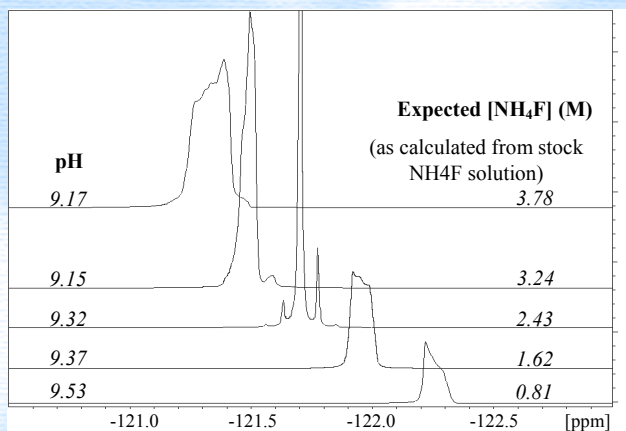


FUJIFILM Dimatix DMP-2831 piezoelectric inkjet printhead.

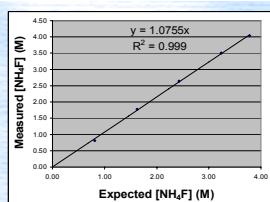
OBJECTIVES

- To quantify fluoride species in solution before and after the jetting (printing) process.
- To determine whether etching of SiO₂ in the silicon printheads occurs by detection of etch products (e.g., SiF₆²⁻) in the solution after jetting,

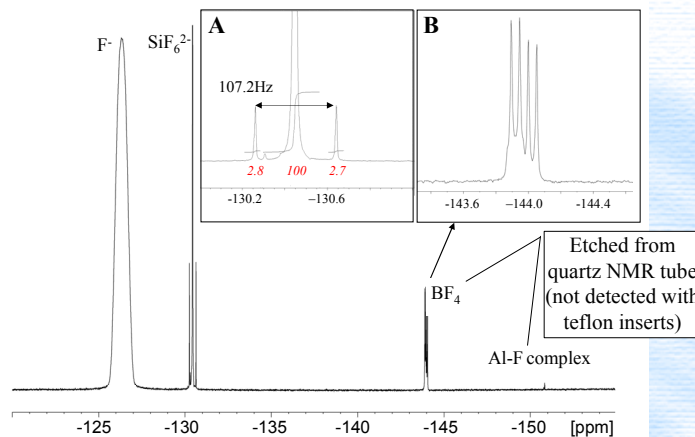
QUANTIFICATION OF FLUORIDE SOLUTIONS



^{19}F NMR spectra of NH_4F solutions containing 20% (v/v) PEG 400. Sodium trifluoroacetate (TFA; ~ 80 mM in D_2O) was added as a quantitation standard.

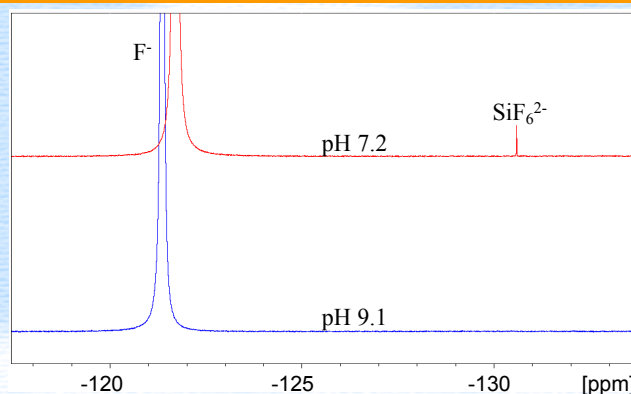


SPECTRAL IDENTIFICATION OF ETCH PRODUCTS



^{19}F NMR spectrum was recorded for a dilute $\text{HF}/\text{NH}_4\text{F}$ solution which had been used to etch a 300 nm thick oxide layer from a silicon wafer (etching supernatant).

DETECTION OF ETCHING IN JETTED SOLUTIONS



^{19}F NMR spectra (using teflon inserts) of solutions collected from the print head nozzles (i.e., after jetting).

Sample	pH 7.2		pH 9.1	
	[F ⁻] (M)	[SiF ₆ ²⁻] (mM)	[F ⁻] (M)	[SiF ₆ ²⁻] (mM)
Before jetting	3.45	-	3.23	-
After jetting	3.75	1.1 ¹	3.97 ²	-

¹ Number of firing nozzles and duration of collection time were not controlled.
² Increased [F⁻] likely due to dehydration and thus depended on collection time.

CONCLUSIONS

- ^{19}F NMR was used to detect etching of SiO₂ in silicon printheads by NH_4F solutions.
- This etching can be reduced by raising the pH of the NH_4F jetting solution from 7.2 to 9.1.
- NMR spectroscopy may be a useful way to characterise jetting processes, however controlled collection of jetting samples is required for quantitative interpretation.

REFERENCES

1. Zhao, J., Wang, A. and Green, M. (1999) *Prog. Photovolt. Res.*, **7**, 471-474.
2. http://www.unsw.edu.au/news/pad/articles/2008/nov/Solar_record.html
3. Lennon, A., Utama, R., Ho-Baillie, A. and Wenham, S. (2008) *Proc. of the Digital Fabrication Conference*, Pittsburgh, 251-255.