Vibrational Sum Frequency Generation Spectroscopy Microscope

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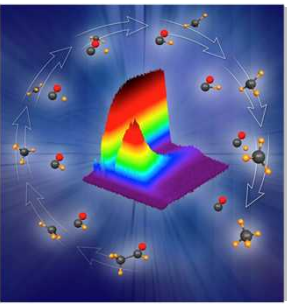

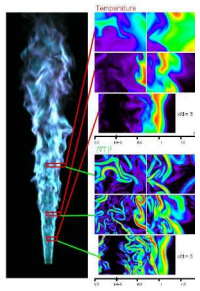

- Background
- Design
- Current Progress

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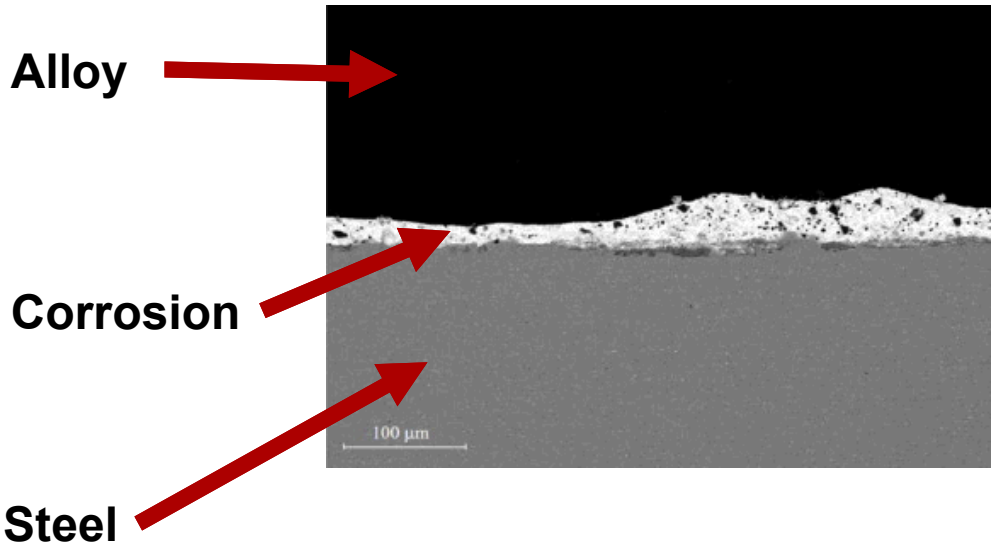
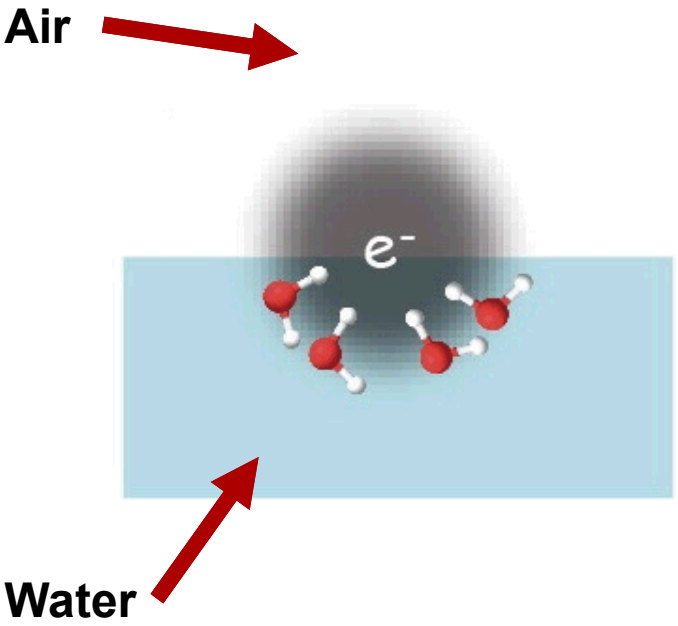
Motivation

- Many chemical and physical phenomena depend on surfaces

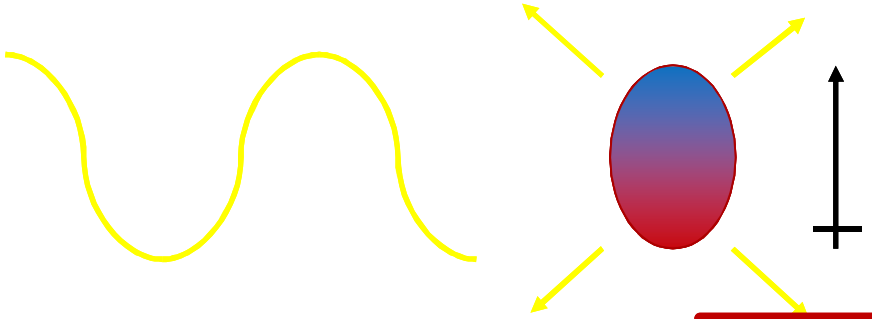




- Surface-specific signal is weak compared to bulk-specific signal

- Fosca Di Gabriele et. al. *Nucl. Eng. Des.* **2014**, 280, 69-75
- Korenobu Matsuzaki et. al. *J. Am. Chem. Soc.* **2016**, 138, 7551-7557

Sum Frequency Generation



$$\mathbf{P} = \varepsilon_0 \chi^{(1)} \mathbf{E}$$

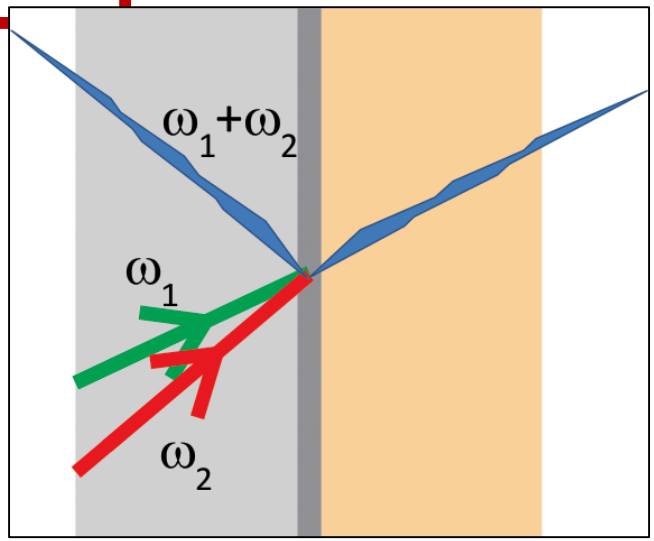
$$\mathbf{P} = \varepsilon_0 (\chi^{(1)} \mathbf{E} + \chi^{(2)} \mathbf{E}^2 + \chi^{(3)} \mathbf{E}^3 + \cdots)$$

$$\mathbf{E} = \mathbf{E}_1 \cos \omega_1 t + \mathbf{E}_2 \cos \omega_2 t$$

$$\mathbf{P}^{(2)} = \varepsilon_0 \chi^{(2)} (\mathbf{E}_1 \cos \omega_1 t + \mathbf{E}_2 \cos \omega_2 t)^2$$

rearranging as before

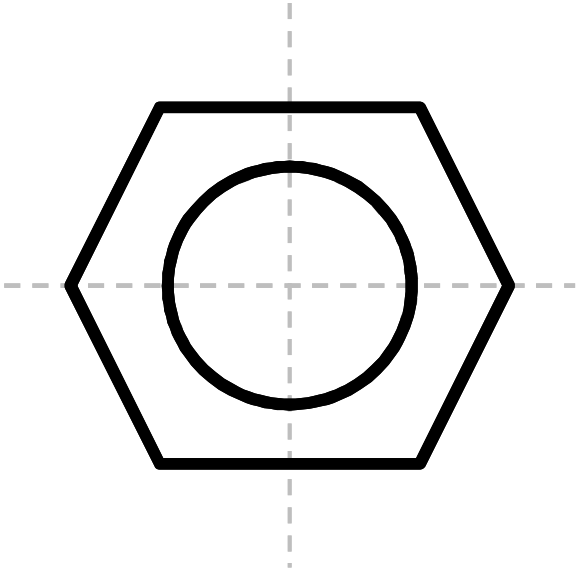
$$\mathbf{E}_1^2 + \mathbf{E}_2^2 \qquad \mathbf{E}_1^2 \cos 2\omega_1 t + \mathbf{E}_2^2 \cos 2\omega_2 t \qquad \tfrac{1}{2}\mathbf{E}_1\mathbf{E}_2 \cos(\omega_1 - \omega_2)t \qquad \boxed{\tfrac{1}{2}\mathbf{E}_1\mathbf{E}_2 \cos(\omega_1 + \omega_2)t}$$

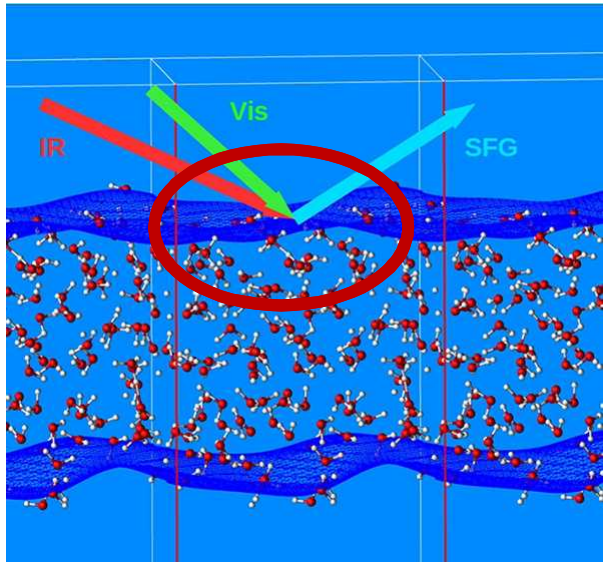


- Lambert, A. G., Davies, P. B., Neivandt, D. J. *Appl. Spectrosc. Rev.* **2005**, 40, 103-145
- Shen, Y. R. *J. Phys. Chem. C* **2012**, 116, 15505-15509

Sum Frequency Generation

- Selection rules allow sum frequency generation (SFG) if it takes place in an asymmetric medium



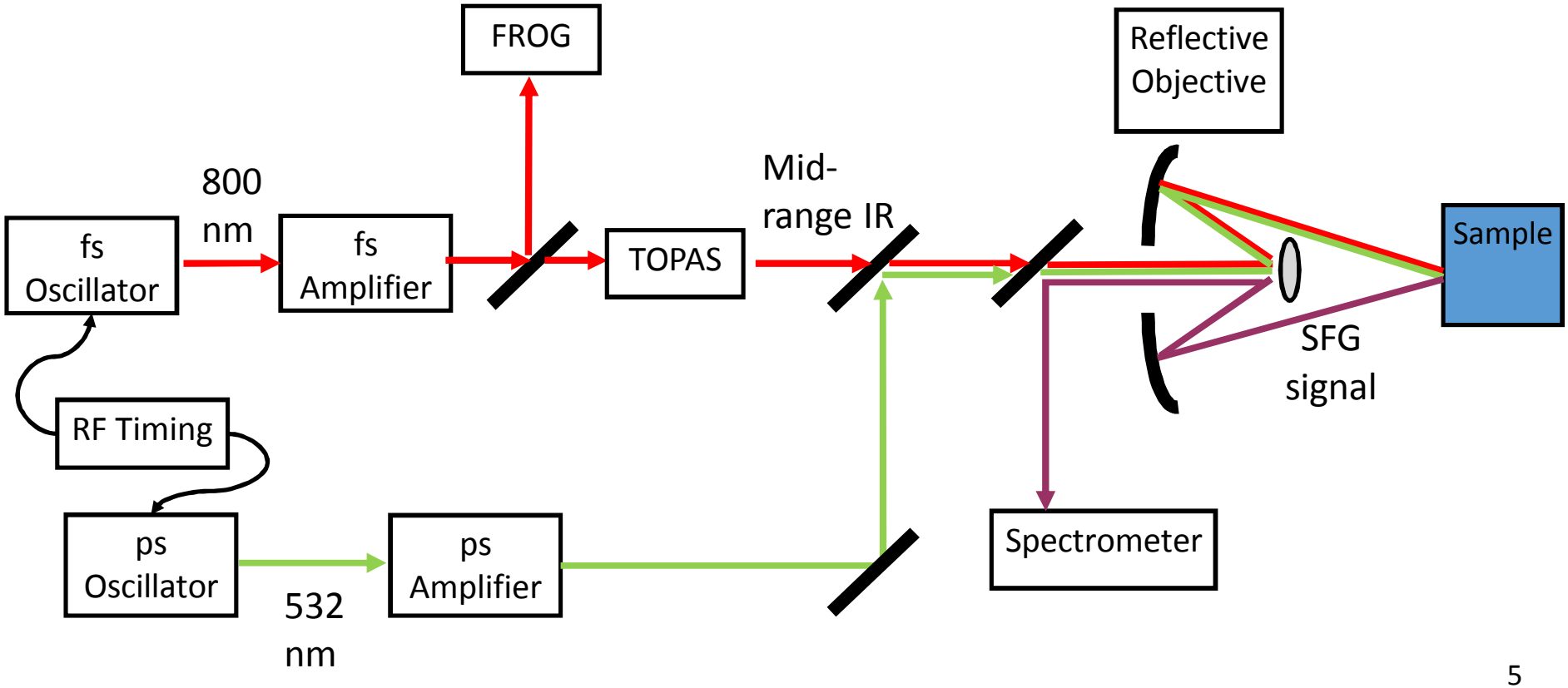


- Sum frequency generation is a non-linear spectroscopic method that is surface-specific

- Marialore Sulpizi. *J. Phys. Chem. Lett.* **2013**, 4, 83-87

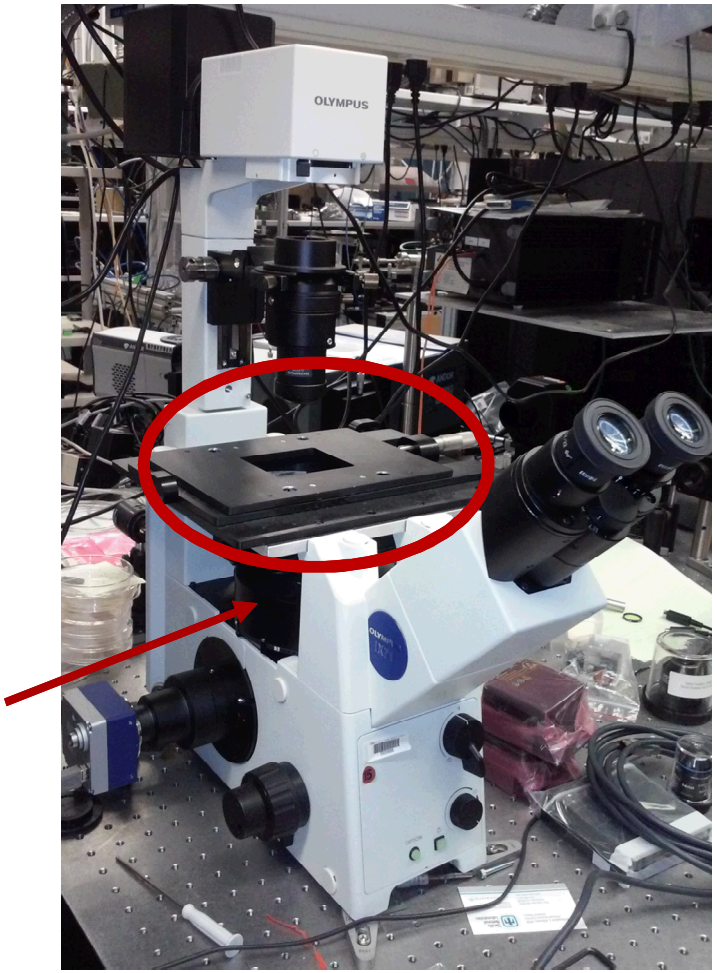
Experimental Setup

- Goal: to construct an SFG microscope
- Beamline Setup:

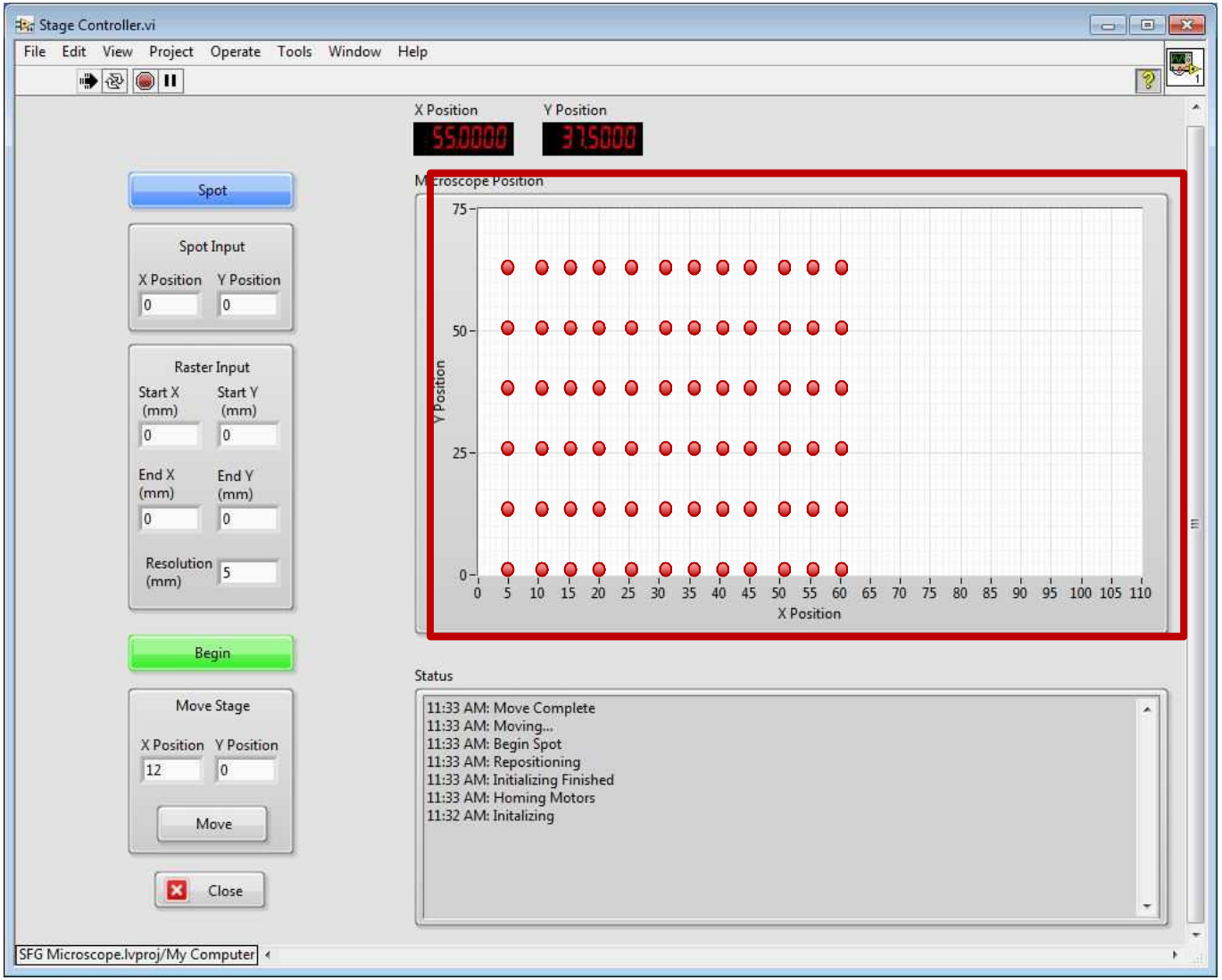


Experimental Setup

- Olympus optical microscope
- Thorlabs xy-stage
- Reflective Optic
- (500 – 20000 nm)



Current Progress

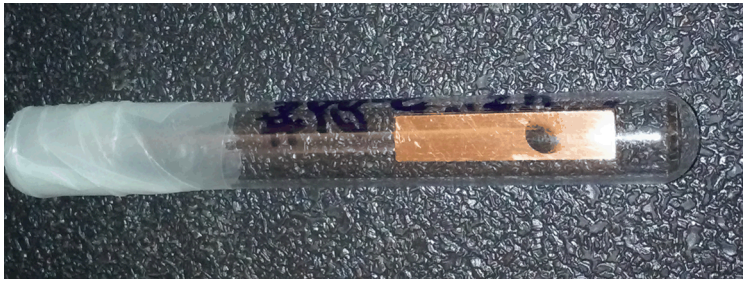


Conclusion

- SFG spectroscopy is a non-linear surface specific method
- Sum frequency generation spectroscopy microscope from optical microscope, xy-stage, and wide wavelength range reflective optic
- LabVIEW control software has been created

Future Work:

- Installing microscope into beam line
- Potential topics: energetic materials degradation and soot formation.



Acknowledgements