FARADAY
TECHNOLOGY, INC.

FARADAYIC Electropolishing of Niobium in an HF-Free Electrolyte

M. Inman, E.J. Taylor and A Lozano-Morales
Faraday Technology, Inc., Clayton, Ohio

6th SRF Materials Workshop
February 18-20, 2010
Tallahassee, FL

FARADAYIC Waveform

"Tuned" to:

enhance mass transfer

control current distribution

➔ polishing

⇩

High instantaneous i at low i_{avg}

"Tuned" to:

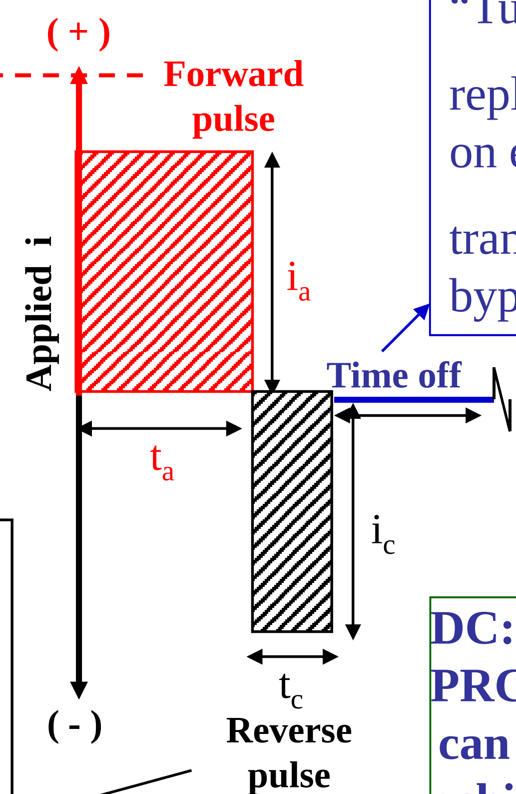
depassivate surface

➔ eliminate need for HF

critical for passive alloys

⇩

Eliminates pitting, allowing uniform etching



"Tuned" to:

replenishment of reacting species on electrode surface

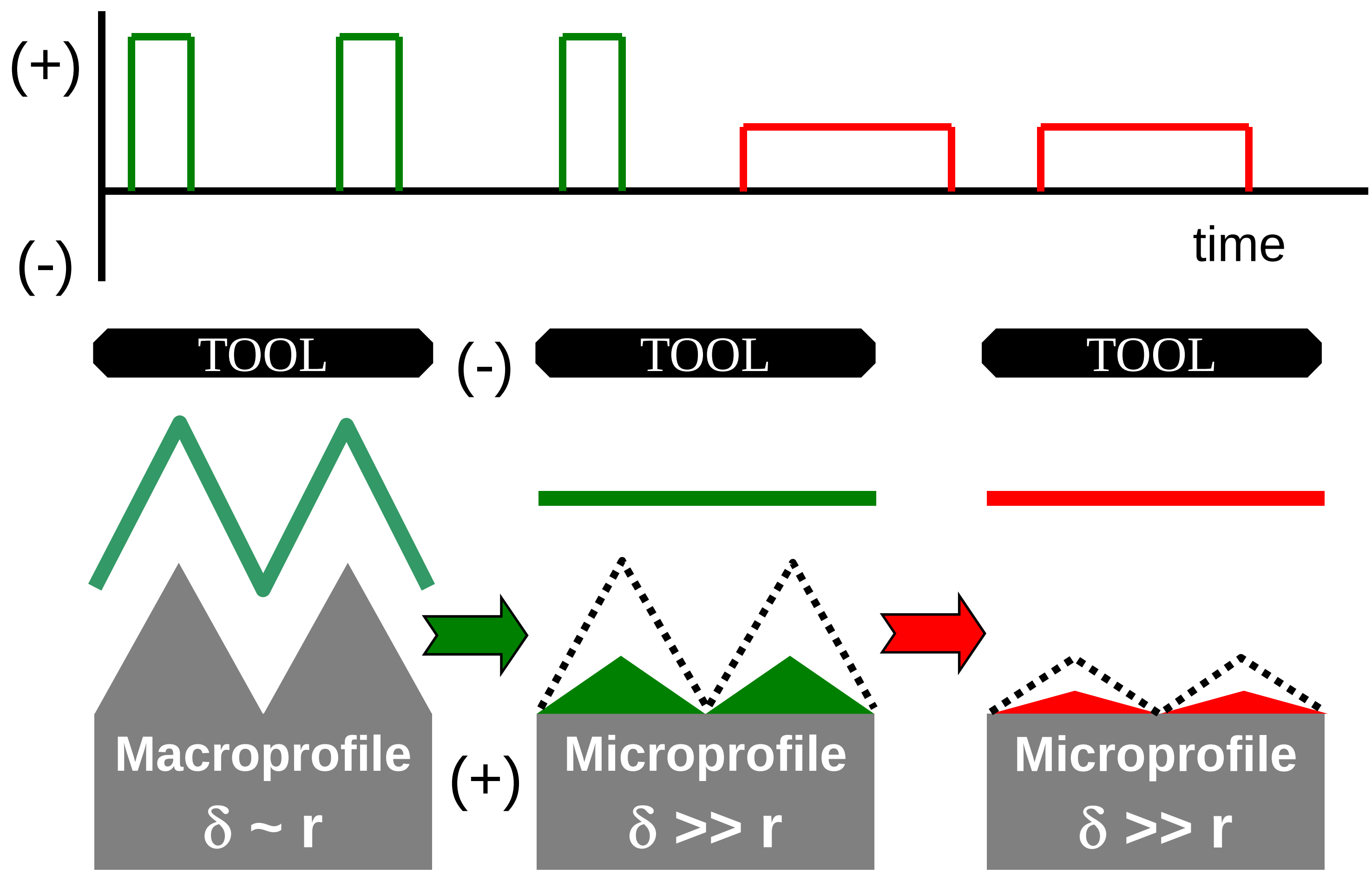
transport of undesirable byproducts from electrode surface

DC: only i_{avg} can be chosen
PRC: i_a, t_a, i_c, t_c
can be varied independently to achieve a desired surface finish and electropolishing rate

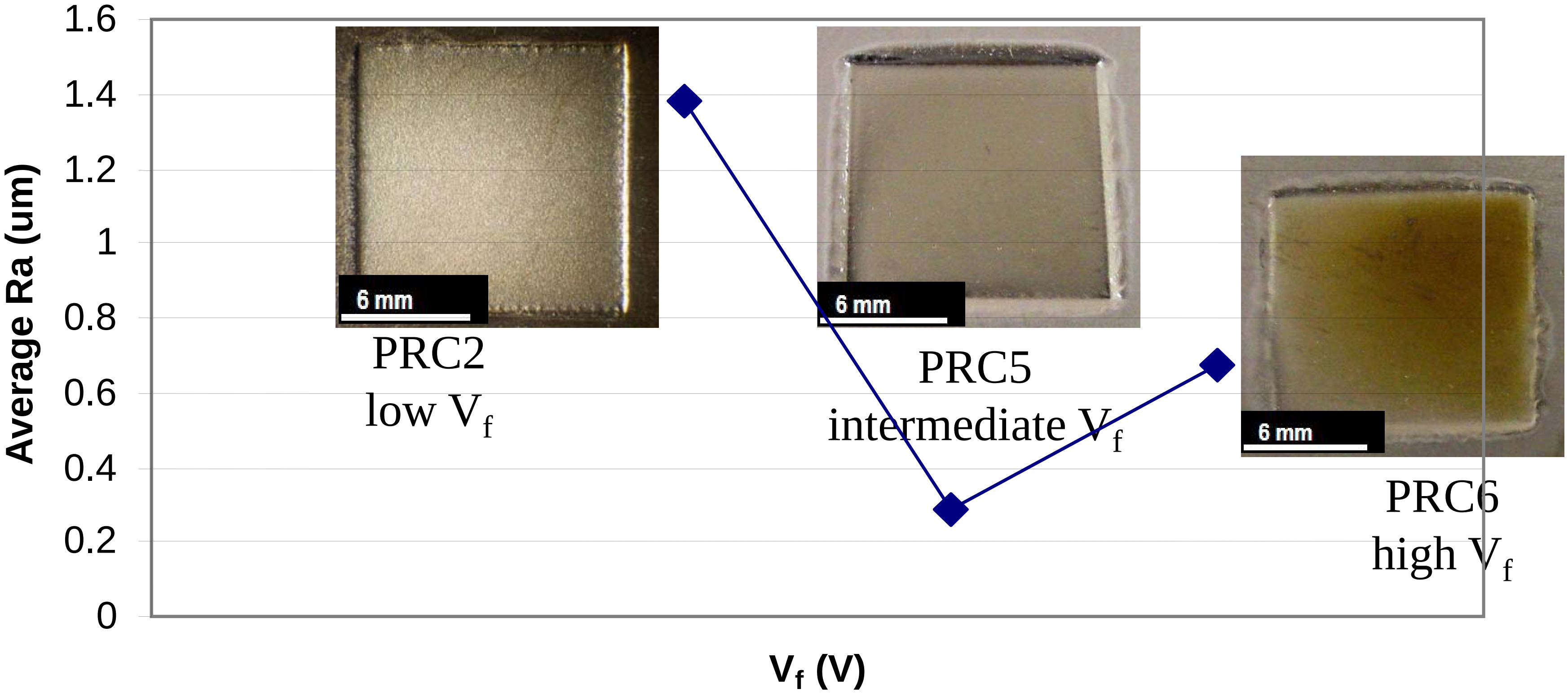
Provides fundamental guidance
NOT
Predictive theoretical model

FARADAYIC Sequenced Waveform

- Viscous salt film typically encountered in DC electropolishing - we don't know if FARADAYIC Electropolishing has the same viscous film – but it works!
- FARADAYIC Control Mechanism is pulse waveforms to manipulate current distribution / inner boundary layer
  - Reverse pulse (not shown) to depassivate surface - replace HF function



Effect of Peak Voltage on Ra

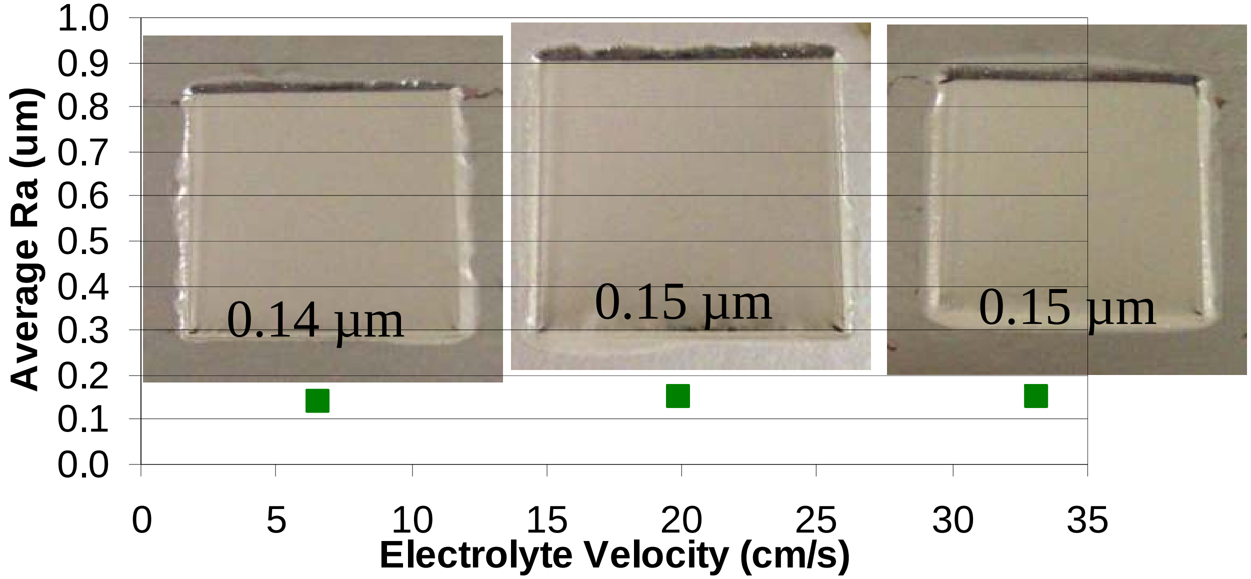


Other FARADAYIC process parameters (frequency, D_f and V_r), were kept the same.

Slide 4

MI2 It would be good to include "details" for PRC5 and PRC6, much as you did for PRC1-4, table form perhaps. Again, links back to the earlier slide and enables your audience to make a connection.
Dr. Inman, 4/29/2009

Effect of Electrolyte Velocity on Ra

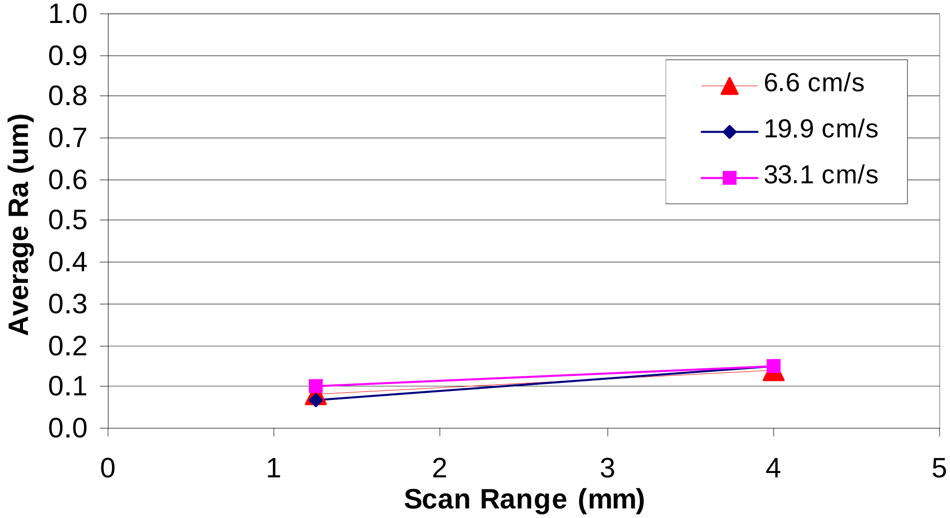


1. There did not appear to be a significant effect of electrolyte velocity when electropolishing Nb.
2. However, results at an electrolyte velocity of 0 cm/s suggested that there must be some degree of agitation in order to achieve uniform, smooth polishing of the Nb surface.

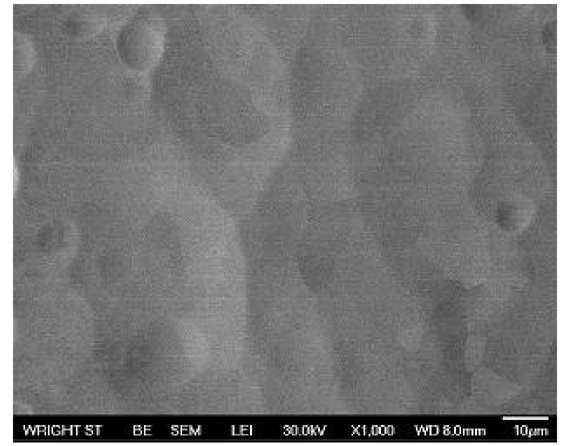
Characterization

Stylus Profilometer

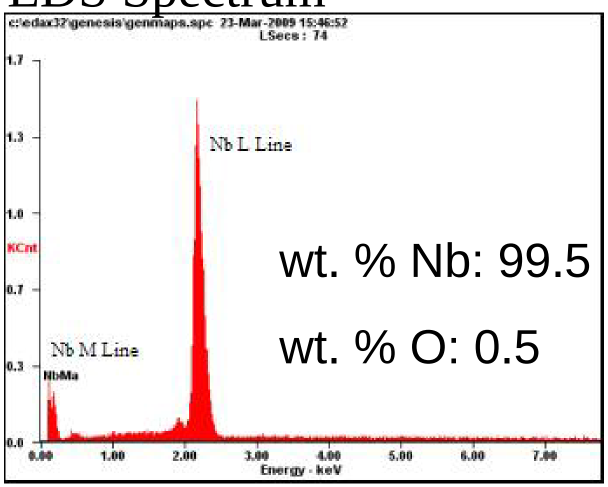
Average surface roughness, Ra vs scan length



SEM micrograph



EDS Spectrum



There was no evidence of impurities present on the Nb surface using EDS analysis.

Conclusions To Date

	Chemical Polishing	Conventional Electrochemical Polishing	FARADAYIC Electropolishing
Electrolyte	$HF/HNO_3/H_3PO_4$	HF 10% / H_2SO_4 90%	20% H_2SO_4
Hydrofluoric acid	Yes	Yes	No
Control Mechanism	Viscous boundary layer	Viscous boundary layer	Pulsed waveform
Etch Rate (µm/min)	1	0.5	Up to 5
Ra (µm)	1	0.1	0.15
Temperature	15 (chilled)	30-35 (chilled)	RT

- Unlike chemical and conventional electropolishing, the FARADAYIC Process does not use hydrofluoric acid, and can potentially achieve high electropolishing rates while maintaining the desired surface finish.
- Limited feasibility work to date, but shows promise.
- Successfully implemented technical approach at industrial scale for other applications, e.g., aerospace and electronics

Acknowledgements: Work for this presentation has been supported by a DOE Phase I SBIR program (DE-FG02-08ER85053) & Faraday Technology, Inc. research funding.