

cyclotronroad

& FUNDING FOR U.S. HARD TECH START-UPS

Christina Chang

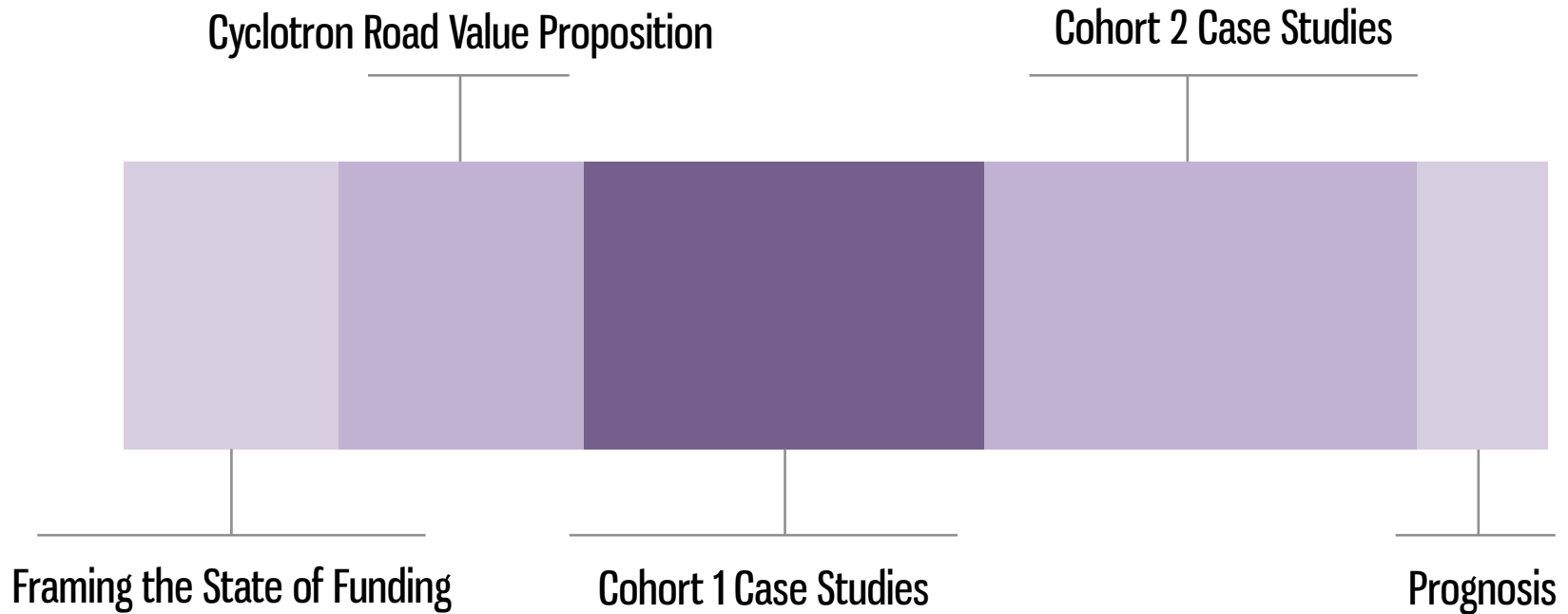
G3 in Chemistry

MSc in Sustainable
Energy Futures

HEJC Nov 8, 2016

PRESENTATION STRUCTURE

Talk roadmap.



THE STATE OF CLEAN TECH FUNDING

PART 1



Files for bankruptcy in Aug 2011

“cronyism approach to the marketplace”

-Rep. Jim Jordan of Ohio

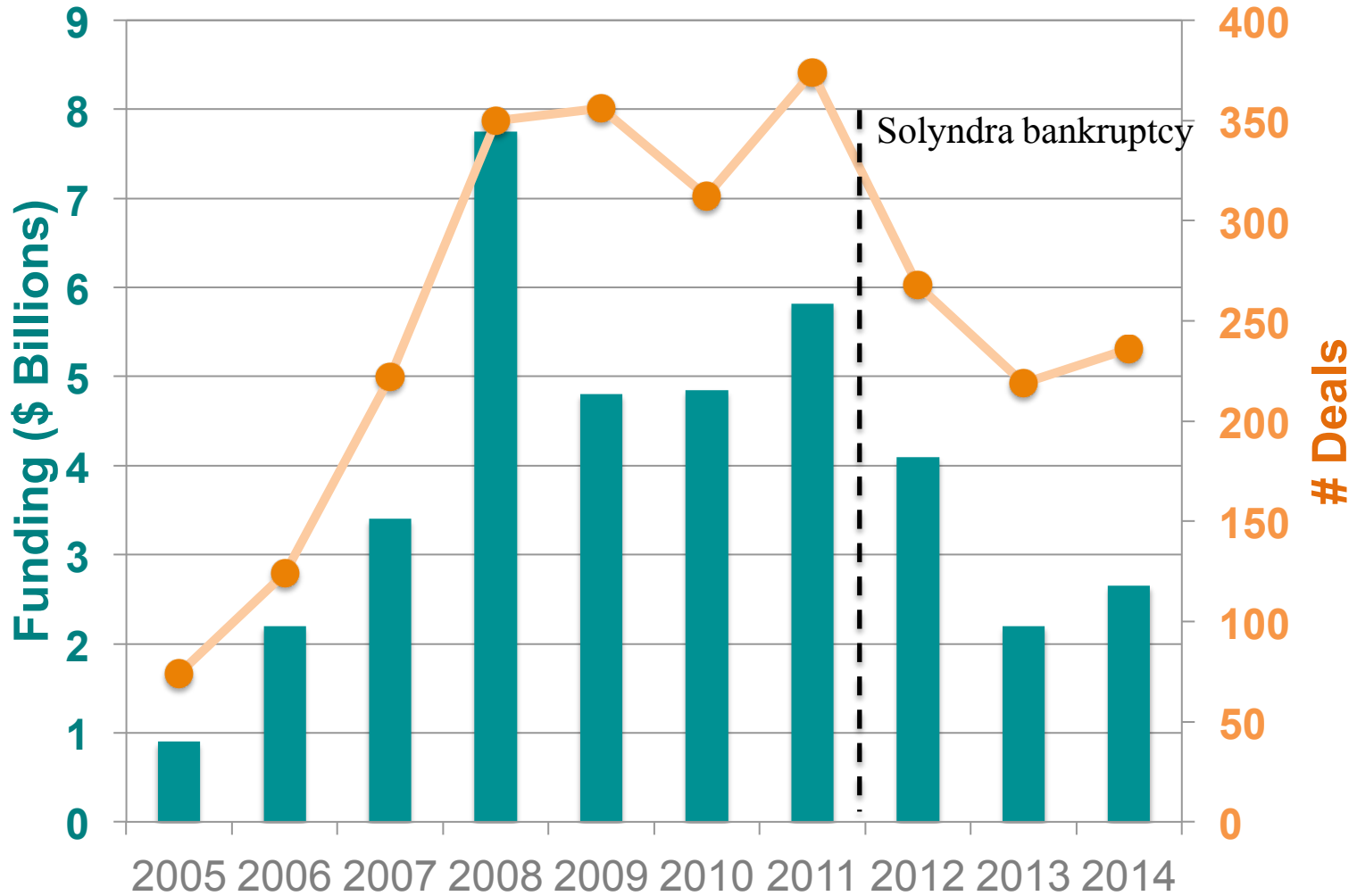
“Obama clean energy loans leave taxpayers in \$2.2 billion hole”

- The Washington Times

“pattern of false and misleading assertions”

- Washington Post

VC FUNDING FOR CLEAN TECH IS NOT STEADY

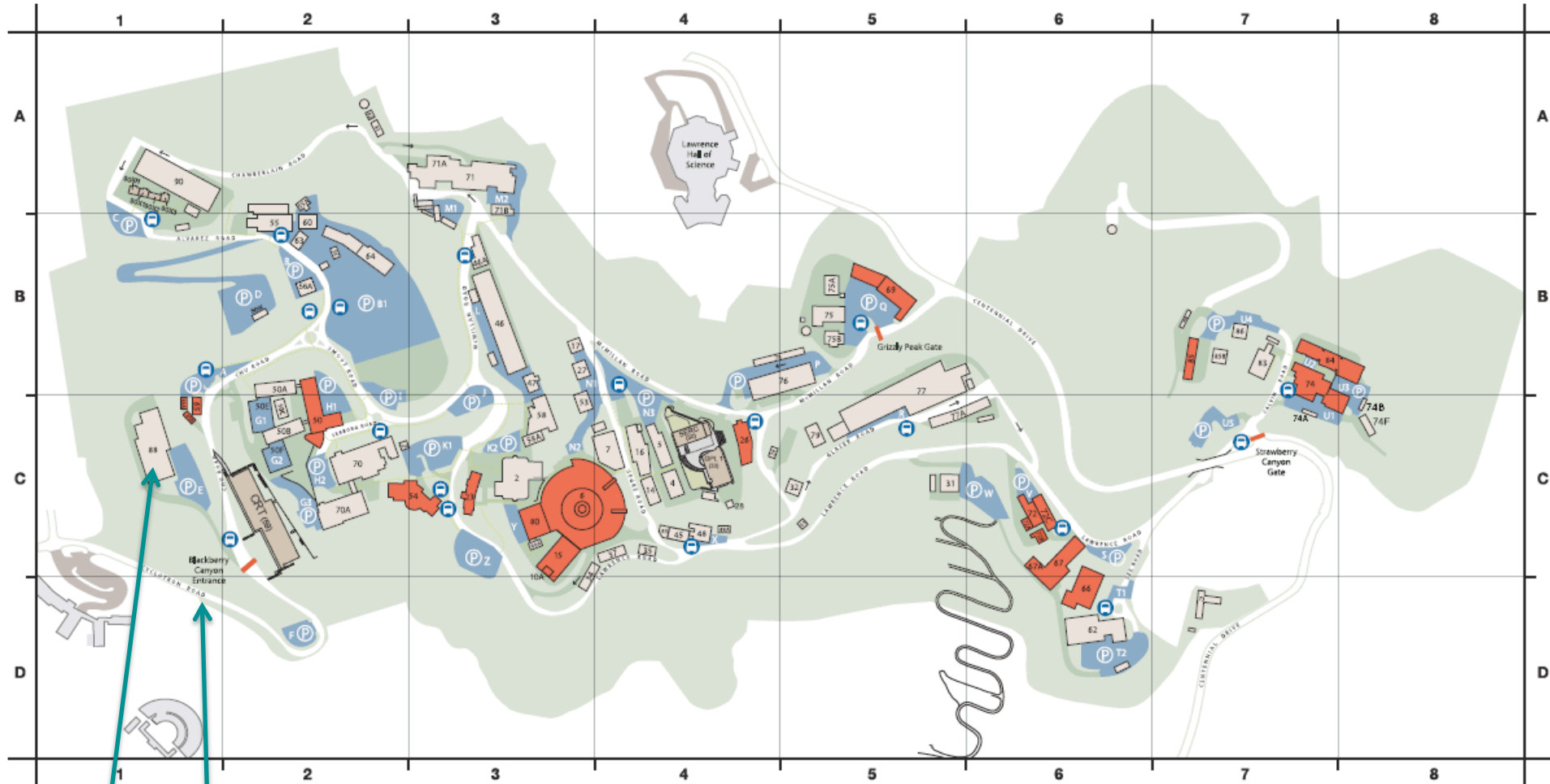




“ “ You can't just hand
them a Science paper. ” ”

A NEW IDEA FOR A HARD TECH INCUBATOR

Map of Lawrence Berkeley National Laboratory



cyclotron

Cyclotron Road

CYCLOTRON ROAD AIMS TO BRIDGE THE GAP



ETOSHA CAVE

Co-Founder & Chief Science Officer, Opus 12

[LINK](#)

CYCLOTRON ROAD PROVIDES ITS FOUNDERS:



A runway to get started

- Personal stipend, travel allowance, and health benefits for up to two years
- Dedicated lab and office space
- Support obtaining additional project funds



World-class R&D support

- \$820 million annual budget
- 4,200 employees
- 13 Nobel prizes
- Nearly 100 members of the National Academies



Unparalleled training and network

- Guidance on critical technology and manufacturing challenges from **our team**
- Educational programming focused on hard technology entrepreneurship
- Support and mentorship from our Advisory Network
- Connections to commercial partners and investors
- Cyclotron Road community and alumni network

SOME EXAMPLE CYCLOTRON ROAD STARTUPS



cohort 1

Opus¹²
MOSAIC MATERIALS
PolySpectra

cohort 2

Feasible
Iris PV

COHORT 1

PART 2A

OPUS¹²

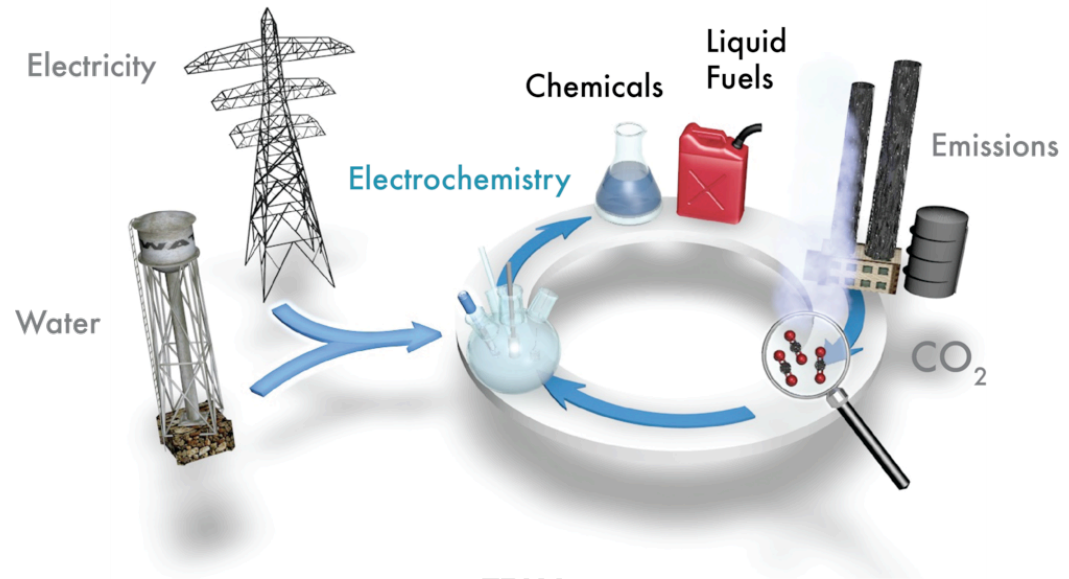
PROOF OF CONCEPT

synthesis of some desired products

CHALLENGES

scalability, selectivity

IDEA
recycle CO₂ into chemicals and fuels using an electrochemical process



TEAM

Kendra Kuhl, Nicholas Flanders, Etosha Cave, Prof. Tom Jaramillo, Stanford



PROOF OF CONCEPT
synthesis of some desired
products

CHALLENGES
scalability, selectivity

Electrocatalytic Conversion of Carbon Dioxide to Methane and Methanol on Transition Metal Surfaces

Kendra P. Kuhl, Toru Hatsukade, Etosha R. Cave, David N. Abram, Jakob Kibsgaard, and Thomas F. Jaramillo*

Department of Chemical Engineering, Stanford University, Stanford, California 94305, United States

	E [V] vs RHE	i [mA/cm ²]	% CH ₄	% MeOH	% C ₂ H ₄	% EtOH	% CO	% HCOO ⁻	% H ₂	Total
Au	-0.74	-5.0					87.1	0.7	10.2	98.0
i	-0.68 ± 0.004	-3.4 ± 0.6					97.0 ± 3.7	0.4 ± 0.5	3.0 ± 1.6	100.4
ii	-0.82 ± 0.01	-4.7 ± 0.3					73.8 ± 11.5	0.1 ± 0.2	10.5 ± 3.0	84.4
iii	-0.96 ± 0.016	-5.8 ± 0.7		0.01 ± 0.01			66.6 ± 3.7	0.9 ± 0.6	32.1 ± 9.6	99.6
Ag	-0.97	-5.0					81.5	0.8	12.4	94.6
i	-0.95 ± 0.006	-2.7 ± 0.3					79.8 ± 14.0	1.2 ± 0.06	20.7 ± 12.2	101.7
ii	-1.09 ± 0.012	-5.1 ± 0.6					89.3 ± 9.5	2.6 ± 0.8	12.6 ± 5.3	104.5
iii	-1.35 ± 0.025	-9.0 ± 2.6	0.07 ± 0.08	0.01 ± 0.004		0.06 ± 0.03	39.7 ± 4.0	6.8 ± 2.4	55.8 ± 3.4	102.5
Zn	-1.14	-5.0					79.4	6.1	9.9	95.4
i iii	-1.18 ± 0.011	-2.8 ± 0.3	0.06 ± 0.02				64.0 ± 12.9	15.1 ± 1.3	14.2 ± 13.2	93.4
ii	-1.31 ± 0.009	-4.1 ± 0.1	0.16 ± 0.02	0.04 ± 0.007			78.9 ± 6.4	16.3 ± 1.4	9.3 ± 4.6	107.0
Cu	-1.04	-5.0	33.3		25.5	5.7	1.3	9.4	20.5	103.5 ^a
i ii iii	-1.05 ± 0.008	-5.9 ± 0.1	24.4 ± 1.0	0.02 ± 0.02	26.0 ± 0.4	9.7 ± 0.4	1.1 ± 0.2	2.0 ± 0.2	22.6 ± 1.0	90.7 ^b
Ni	-1.08	-5.0	1.8			0.1		1.4	88.9	92.4 ^c
i ii iii	-1.00 ± 0.006	-4.9 ± 1.3	0.5 ± 0.5	2.3 ± 2.4	0.05 ± 0.04			0.06 ± 0.03	106.4 ± 5.9	109.3 ^c
	-1.04 ± 0.018	-10.2 ± 2.3	0.4 ± 0.4	1.0 ± 0.9	0.02 ± 0.02			0.03 ± 0.01	100.6 ± 22.6	102.1 ^c
Pt	-0.67	-5.0						0.1	95.7	95.8
i iii	-0.67 ± 0.06	-1.6 ± 0.6	0.01 ± 0.01				0.1 ± 0.07	0.1 ± 0.1	92.5 ± 8.2	92.2
ii	-0.75 ± 0.006	-3.9 ± 0.7	0.02 ± 0.02	0.05 ± 0.02			0.1 ± 0.1	0.4 ± 0.5	109.0 ± 10.5	109.6
Fe	-0.51	-5.0							94.8	94.8
i ii iii	-0.54 ± 0.006	-5.3 ± 1.04	0.01 ± 0.002						99.0 ± 7.3	99.0

^aValue includes additional contributions from n-propanol, allyl alcohol, acetaldehyde, and propionaldehyde

^bValue includes above and contributions from hydroxyacetone, acetone, ethylene glycol, and glycolaldehyde

^cValue includes contributions from ethane

Table S2: Data reported by Hori et al. (32) is shown for each metal in row with gray background. Data collected in this study is displayed on white background. i) Denotes data collected at similar potential, ii) denotes data collected a similar current density and iii) denotes data collected at the earliest potential where we observed the formation of hydrocarbons and/or alcohols. Detection of new products is highlighted with blue text.





Mosaic Materials

TEAM

Tom McDonald
Zoey Herm
Prof. Leff Long, Berkeley



IDEA

radically reduce the cost and emissions impact of
chemical separations via highly selective sorbents (MOFs)

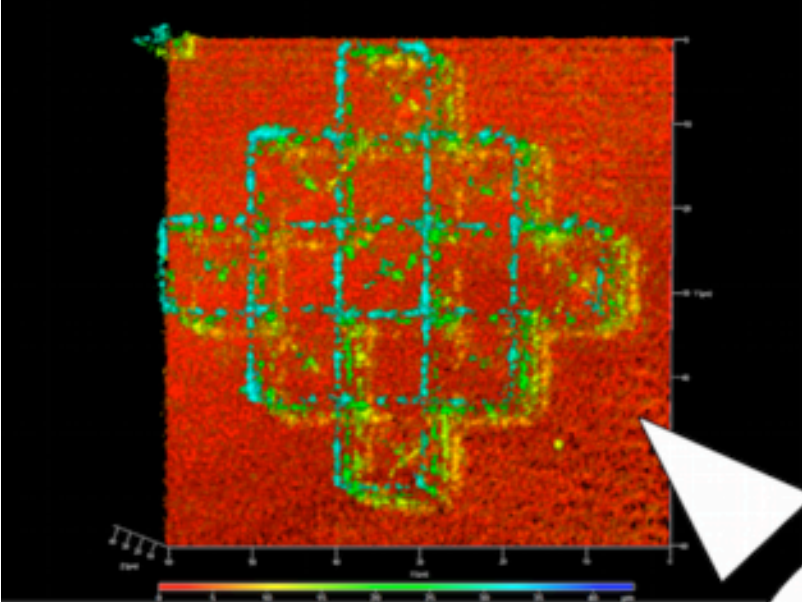


CHALLENGES

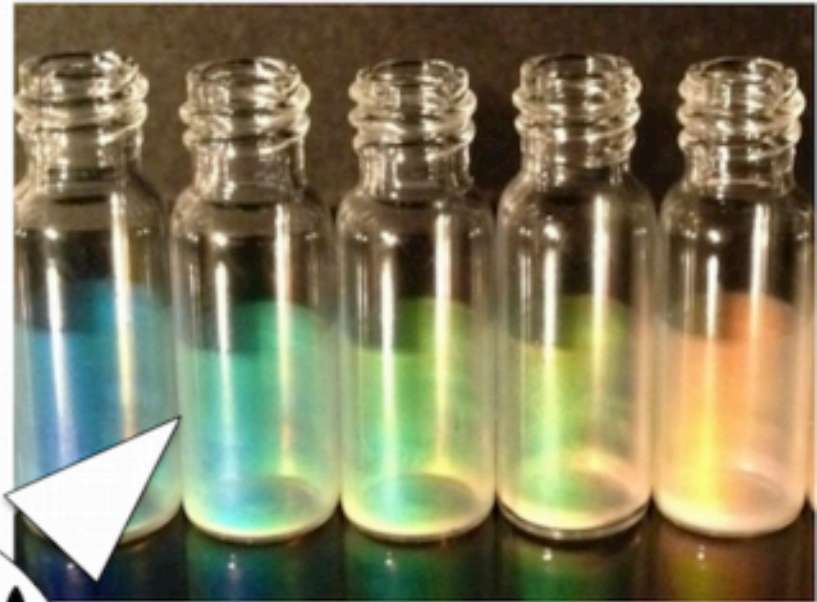
Scale-up of synthesis and particle engineering to meet industry form factor and performance standards.
Investor alignment

3D PRINTING





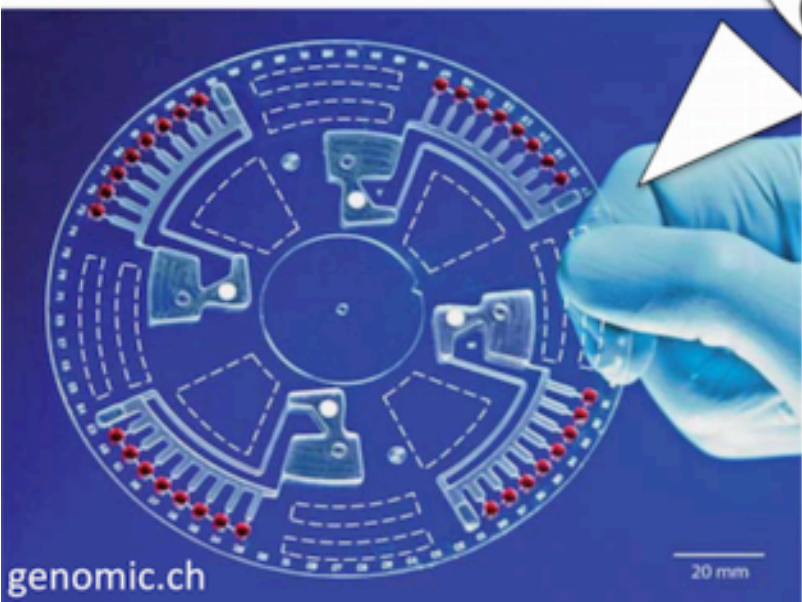
Nanofabrication



Photonic Crystals



Microfluidics & MEMS



genomic.ch

20 micrometers

3D Printing



biocompatible

antifouling

corrosion-resistant

high strength

luminescent

123Dapp.com



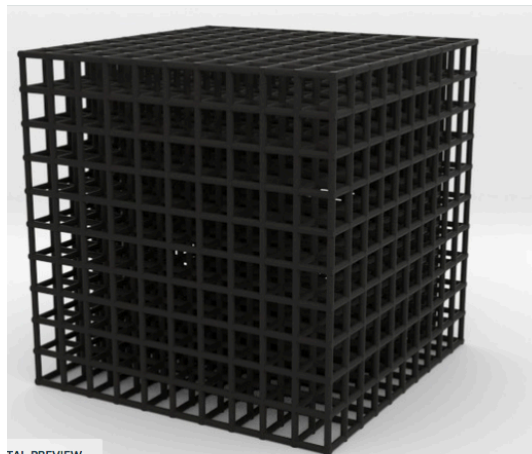
polySpectra

IDEA
a patterning platform for multifunctional materials

TEAM
Coleman Rainey, Aditya Balasubramanian, Corinne Allen, and Raymond Weitekamp



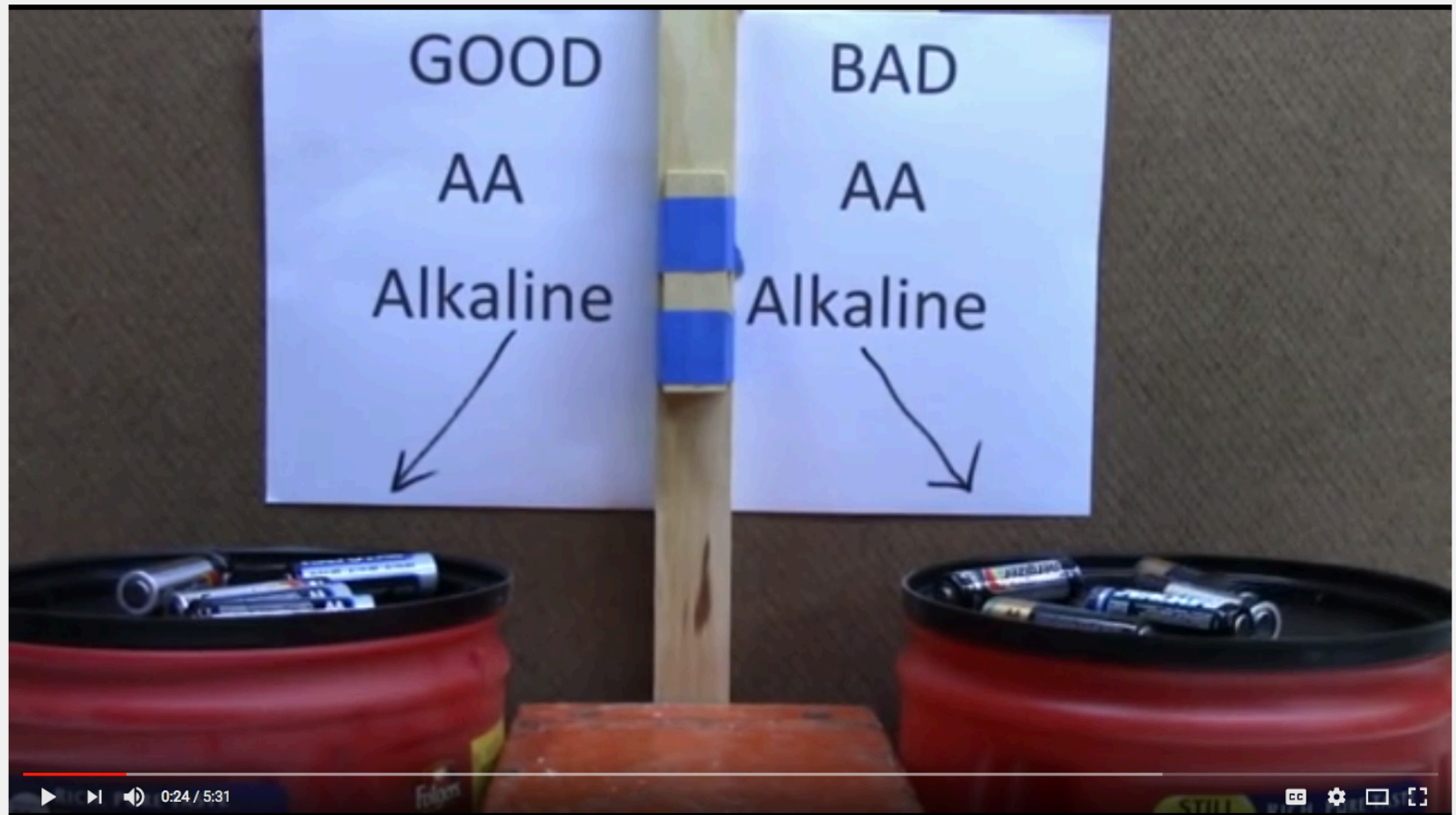
CHALLENGES
Communicating value add



COHORT 2

PART 2B

START-UP INSPIRED BY A YOUTUBE VIDEO

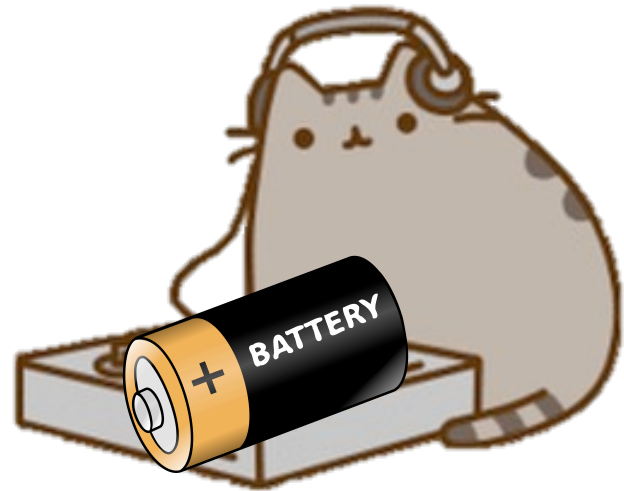


Why A Dead Alkaline Battery Bounces!

[LINK](#)

Explanation: <https://www.princeton.edu/main/news/archive/S42/72/95S25/index.xml?section=topstories>

Feasible

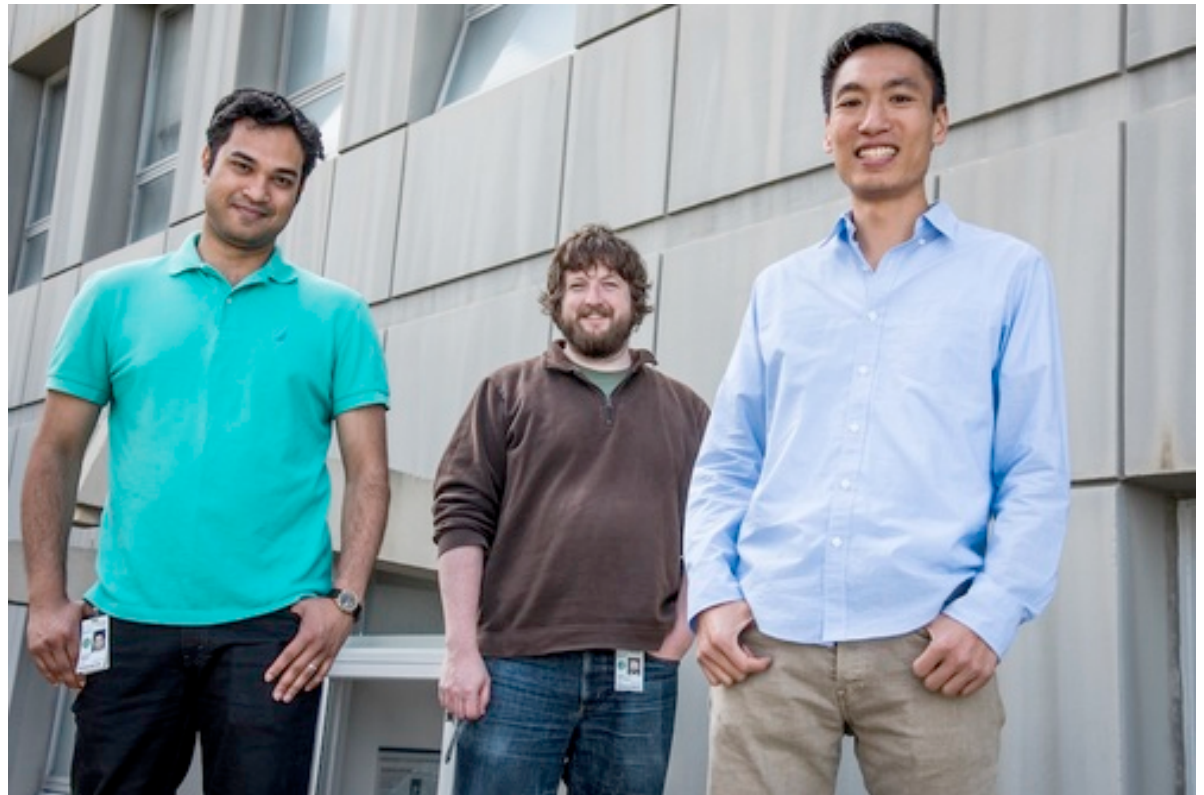


IDEA

equip the battery industry with better diagnostics

TEAM

Shaurjo Biswas, Barry Van Tassel, and Andrew Hsieh





IRIS PV

perovskite – silicon tandem cells

PROOF OF CONCEPT

23.6% efficiency

(Aug 2016)

CHALLENGES

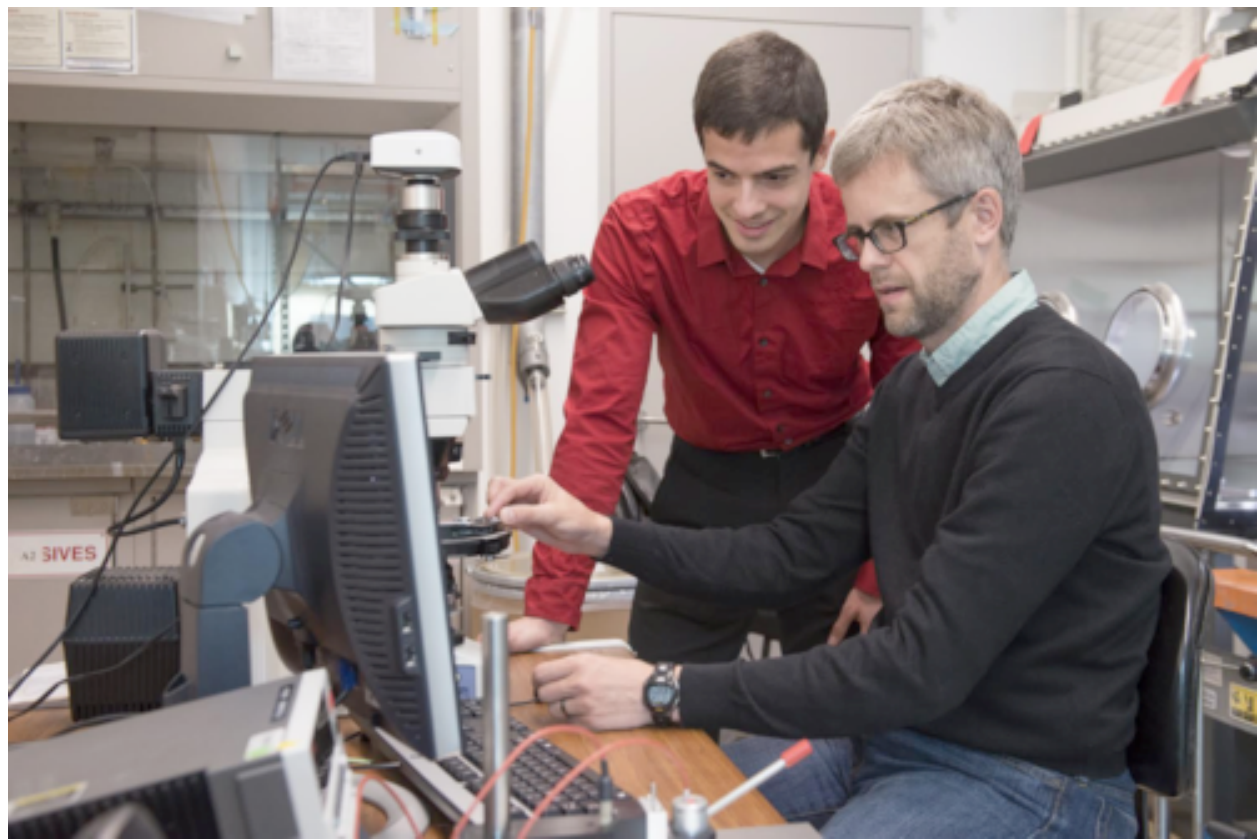
material stability

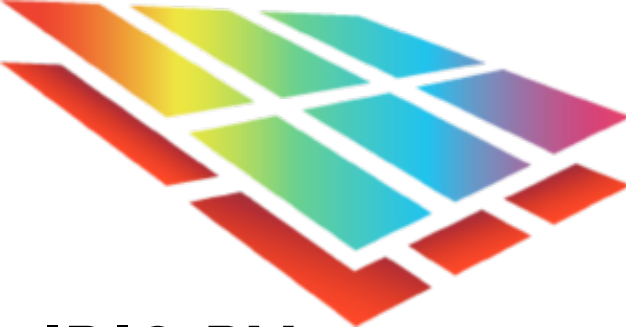
cost:value ratio for

perovskite layer

TEAM

Colin Bailie, Prof. Mike McGehee, Stanford





IRIS PV

perovskite – silicon tandem cells

PROOF OF CONCEPT

23.6% efficiency

(Aug 2016)

CHALLENGES

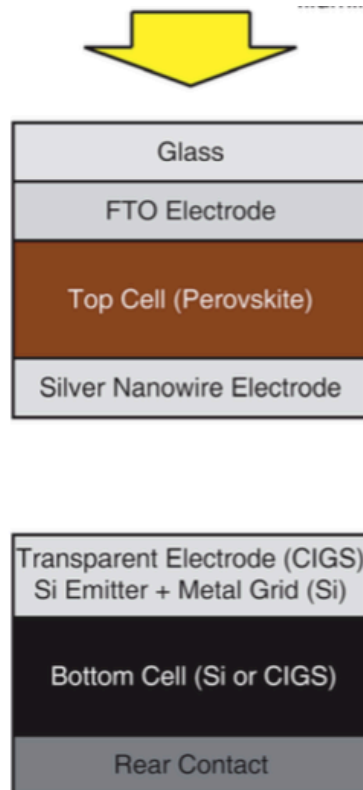
- material stability
- cost:value ratio for perovskite layer
- Competition (Oxford PV, Saule Technologies)



Cite this: *Energy Environ. Sci.*, 2015, 8, 956

Semi-transparent perovskite solar cells for tandems with silicon and CIGS†

Colin D. Bailie,^{‡a} M. Greyson Christoforo,^{‡b} Jonathan P. Mailoa,^c Andrea R. Bowring,^a Eva L. Unger,^a William H. Nguyen,^d Julian Burschka,^{§e} Norman Pellet,^e Jungwoo Z. Lee,^c Michael Grätzel,^e Rommel Noufi,^f Tonio Buonassisi,^c Alberto Salleo^a and Michael D. McGehee*^a



	Iris PV	Oxford PV
Article	EES 2015	Science 2016
Efficiency	12.7 %	15.1 %
PV architecture	Glass	Glass
	FTO	FTO
	mesoTiO ₂	SnO ₂ /PCBM
	MAPbI ₃	Cs _{.17} FA _{.83} Br _{1.2} I _{1.8}
	s-OMeTAD	s-OMeTAD
	AgNW	ITO NP + sputtered ITO

PROGNOSIS

PART 3

PROGNOSIS

Will Cyclotron Road be successful?



C.R. is a start-up itself

Relatively low cost

\$ from variety of sources

Currently attracting talent

“pay it back” if company exits

Strong ecosystem

Cohort 1 attracting outside funding



cyclotronroad

& FUNDING FOR U.S. HARD TECH START-UPS

Christina Chang

G3 in Chemistry

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Energy Futures

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