



# **Ceramic, Composite and Optical Materials Center**

## **Spring 2012 Meeting**

**April 26, 2012**

**Rutgers University**

# **LIFE Summary Report**

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4/26/12

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

### Level of Interest

Title	VI	I	I w/ C	NI	A
(A) Low Temperature Reactive Sintering for Printed Solar Cells	0	2	0	6	1
(B) Densification and Characterization of Transparent Polycryst ...	2	7	0	0	0
(C) Comparison of the Densification and Properties of Stoichiom ...	3	5	0	1	0
(D) Center for Advanced Cutting Tool Technology Review	2	4	0	2	1
(E) Processing of Spinel Powders (New Project)	1	3	0	2	0
(F) Modeling the Densification of Non-Oxide Ceramics	5	2	1	0	0
(G) Modeling Binder Removal (New Project)	4	4	1	0	0
(H) Defining Microstructural Tolerance Limits of Defects for Si ...	3	3	0	0	0
(I) Study of US SiC Powder Variations	3	1	0	2	1
(J) Effect of Machining on Residual Stressing in Ceramics	3	5	1	0	0
(K) Non-Destructive Characterization of Dense Ceramics	2	5	0	1	0
(L) Hydrothermal Purification of Refractory Oxides and Ceramic ...	0	1	0	5	1
(M) High Strength, High Modulus Inherently Flame Retardant Fibe ...	0	1	0	4	1
(N) Optically Active Fibers and Coatings	0	0	0	5	1
(O) Towards Fibers That Will Posses Hydrophobic/Oleophobic Prop ...	0	1	0	3	1
(P) Directional Crystallization of the Mullite Fiber from the P ...	1	3	0	1	1

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

### Level of Company Relevance

Title	High	Moderate	Some	None
(A) Low Temperature Reactive Sintering for Printed Solar Cells	0	0	4	5
(B) Densification and Characterization of Transparent Polycryst ...	2	3	2	2
(C) Comparison of the Densification and Properties of Stoichiom ...	3	3	2	1
(D) Center for Advanced Cutting Tool Technology Review	2	2	4	1
(E) Processing of Spinel Powders (New Project)	0	3	2	1
(F) Modeling the Densification of Non-Oxide Ceramics	2	5	0	0
(G) Modeling Binder Removal (New Project)	2	6	1	0
(H) Defining Microstructural Tolerance Limits of Defects for Si ...	2	0	2	0
(I) Study of US SiC Powder Variations	3	1	2	1
(J) Effect of Machining on Residual Stressing in Ceramics	2	6	1	0
(K) Non-Destructive Characterization of Dense Ceramics	2	4	2	0
(L) Hydrothermal Purification of Refractory Oxides and Ceramic ...	0	0	4	3
(M) High Strength, High Modulus Inherently Flame Retardant Fibe ...	0	1	2	3
(N) Optically Active Fibers and Coatings	0	0	1	5
(O) Towards Fibers That Will Posses Hydrophobic/Oleophobic Prop ...	0	1	0	4
(P) Directional Crystallization of the Mullite Fiber from the P ...	0	1	3	2

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (A) Low Temperature Reactive Sintering for Printed Solar Cells**

**Project PI: Dunbar Birnie (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 0	High - 0
Interested - 2	Moderate - 0
Interested with Change - 0	Some - 4
Not Interested - 6	None - 5
Abstain - 1	

### Interested

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- Laminate structures  
Directional solidification  
Colloidal processing
- Curious whether you have investigated other methodology with other chemistries? How about higher temperature hot side applications?

### Not Interested

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- We are investigating clean energy as future market space. Depending on our findings, thermoelectrics may become an area of interest.
- Focus on sintering and microstructure development fits center as a whole. PbTe material is outside of our company scope.
- Lead compounds and other toxic materials are difficult materials for larger companies to work with.

### Abstain

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- I did not hear whole talk.

## LIFE Form Review

### Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012

**Project: (B) Densification and Characterization of Transparent Polycrystalline Spinel**  
**Project PI: Rich Haber (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 2	High - 2
Interested - 7	Moderate - 3
Interested with Change - 0	Some - 2
Not Interested - 0	None - 2
Abstain - 0	

#### Very Interested

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- Interesting concept to increase mechanical properties.

One interesting aspect would be to determine if these boundaries may help with crack deflection. Maybe not the case with alumina because of the tight bonding, but interesting to see the effects.

- Current transparent spinel is very weak - which limits its use. Typical armor systems require lamination of glass or polymer materials to the spinel. The difference in thermal expansion between the spinel and backing materials results in cracking of the spinel in thin parts. Current spinel parts fail the commercial scanner window requirements - again because of low strength - sapphire passes

#### Interested

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- The topic is not of interest directly, but some peripheral outcomes of the project are of interest to apply in other material systems.  
Our interests will be to know the principles of making high purity materials without grain growth and defects. Potential applications are in machining at high temperature reducing chemical reactivity with work pc and increasing strength, or high strength materials for corrosion resistance.
- Looking forward to extension of project to Y<sub>2</sub>O<sub>3</sub> dopant. What is statistical confidence of hardness improvement for alumina doped samples?
- Tracking dopant distribution from green to fired
- Academic interest only so far.
- Too early to comment at this point. Should reach out to Gary Gilde at ARL.

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (C) Comparison of the Densification and Properties of Stoichiometrically Modified Boron Carbide**

**Project PI: Rich Haber & Fatih Toksoy (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 3	High - 3
Interested - 5	Moderate - 3
Interested with Change - 0	Some - 2
Not Interested - 1	None - 1
Abstain - 0	

### Very Interested

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- With project as part of industrial consortium, important to keep in mind how findings in SPS will translate to current more manufacturing friendly sintering techniques. Consider occasional check of Rutgers made B4C sintered via more traditional techniques.
- This is important work for us and will be very important in the MEDE/CRA.
- Excellent work. Was this material ground (after carbothermal processing)?

### Interested

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- Tougher, stronger B4C solid than can be made by HP is of interest. Possible application - machining (cheaper substitute for PCD, cBN) and wear components.
- Better B4C powder is required - but in reality there needs to be a positive cost / benefit result. Dow discontinued the work because of scale up issues and higher than anticipated operating cost.  
hot pressing of large parts - 18" x 22" requires B/C ratio to be below 4.0.
- Corn starch is an interesting addition in getting small particle sizes.
- Very nice work. we would be interested in acquiring some of your powder in the future.

### Not Interested

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- Cool processing project

Starch has ash (I.e. phosphate)

Candy: sugar and boric acid

## LIFE Form Review

### Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012

**Project: (D) Center for Advanced Cutting Tool Technology Review**

**Project PI: Patrick Kwon (Michigan State University)**

Level of Interest	Level of Company Relevance
Very Interested - 2	High - 2
Interested - 4	Moderate - 2
Interested with Change - 0	Some - 4
Not Interested - 2	None - 1
Abstain - 1	

#### Very Interested

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- Very interested in participating in learning from the center activities
- We welcome msu to ccomc.

#### Interested

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- Maching of Titanium is still very costly - anywork relating to reducing the cost of machining Titanium is very worth while
- Support bringing Michigan State into the center under the thrust of hard materials. Likely but not obvious connection to businesses in Saint-Gobain - to be investigated.
- Machining of composite materials would interest our company.

#### Not Interested

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- Friction and wear of process equipment, too
- Seems like useful information but not of interest, except perhaps the addition of nanographene to lubricants.

#### Abstain

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- May be of interest - don't know yet.

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (E) Processing of Spinel Powders (New Project)**

**Project PI: Rich Riman (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 1	High - 0
Interested - 3	Moderate - 3
Interested with Change - 0	Some - 2
Not Interested - 2	None - 1
Abstain - 0	

### Very Interested

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- This could be very important for reducing the cost of spinel powder and the quality and reproducibility of the powder.

### Interested

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- Interested in BOTH the material productin aspect AND the in-situ monitoring aspect. Please confirm cost estimate graph (vs ton or kg) - believe it to be per kg.
- Atmospheric modeling with nitrogen or argon gas flow to simulate sintering would be useful.

### Not Interested

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- - Future project
  - Might be interesting to do hydrothermal of porous and non porous surfaces.
- I did nto hear papaer - not here (on) 4/25.



## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (F) Modeling the Densification of Non-Oxide Ceramics**

**Project PI: John Matthewson & Rich Haber (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 5	High - 2
Interested - 2	Moderate - 5
Interested with Change - 1	Some - 0
Not Interested - 0	None - 0
Abstain - 0	

### **Very Interested**

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- Very good information. Model will be useful in large furnace SiC loading, and ability to predict heating as thickness of parts change
- Key will be translating findings (specifically with regards to scenario where T gradient has colder center) to impact on furnace, sintering, densification.
- Our company would be interested in:  
changing from a vacuum to a non-vacuum and the effects on time for CO removal  
  
and... the nitriding of Si
- Very good work. What about the effect of vacuum (on model)?
- This is an elegant process modeling project and provide tools to systematically optimize SiC and B4C processing.

### **Interested**

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- Interesting gradients and redistributions

### **Interested with Change**

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- Will be interested in learning about oxygen control in silicon nitride and sialon sintering.

## LIFE Form Review

### Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012

**Project: (G) Modeling Binder Removal (New Project)**

**Project PI: John Matthewson & Rich Haber (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 4	High - 2
Interested - 4	Moderate - 6
Interested with Change - 1	Some - 1
Not Interested - 0	None - 0
Abstain - 0	

#### Very Interested

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- Would like to see SiC and phenolic resins investigated
- Will get back to John/Rich with feedback on suggested material sets (powder/binder) and possibly some test samples
- Very interesting. What about the mixing of this model with the densification model because not all of the binder is necessarily removed. What about larger open porosity mixed with small closed porosity? What about vacuum systems?

#### Interested

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- - Removal of Methocel type binder
  - Removal of pore former
  - Removal of DPF soot
- Catalytic action of particles
- It might be interesting to study the removal of organics from the same porous ceramic with different organic loadings
- Very important to optimize processing times.
- We have one system where we have water integrated into this system. Would be curious to see if model simulations with binder and the previous oxide talk with integration of water evaporation.
- Very complex problem - of interest to relevant industries involved in manufacturing - possibly ARMY Manufacturing Technology program relevant.

#### Interested with Change

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- Will be interested in learning about oxygen control in silicon nitride and sialon sintering.

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (H) Defining Microstructural Tolerance Limits of Defects for SiC and Al<sub>2</sub>O<sub>3</sub> Armor**

**Project PI: Rich Haber & Dale Niesz (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 3	High - 2
Interested - 3	Moderate - 0
Interested with Change - 0	Some - 2
Not Interested - 0	None - 0
Abstain - 0	

### **Very Interested**

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- Useful commercial information for us. No interest to look at other material sets at this point.
- Very tedious work, but important in the long run for the optimization of SiC.
- Good information. Other types of flaws?

### **Interested**

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- This is more pure science, with little impact on NDE. Phase array ultrasonics - has located some large defects in SiC - and Quasar Ultrasonics will tell you if you have a good or bad part - based on certain internal defects.

## LIFE Form Review

### Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012

**Project: (I) Study of US SiC Powder Variations**

**Project PI: Rich Haber & Vladislav Domnich (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 3	High - 3
Interested - 1	Moderate - 1
Interested with Change - 0	Some - 2
Not Interested - 2	None - 1
Abstain - 1	

#### Very Interested

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- This is a very nice survey of all of this SiC and B4C powder work. Recommend a report be prepared for us to convert to an archival report.
- Nice work; very useful.

#### Interested

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- Agreed with project steps to this point and through the summer - for completion in fall. Agreed key will be thorough summary - useful for corporate members as well.

#### Not Interested

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- Culling and beneficiation opportunity

#### Abstain

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- Good information for powder producers

## LIFE Form Review

### Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012

**Project: (J) Effect of Machining on Residual Stressing in Ceramics**

**Project PI: Rich Haber & Adrian Mann (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 3	High - 2
Interested - 5	Moderate - 6
Interested with Change - 1	Some - 1
Not Interested - 0	None - 0
Abstain - 0	

#### Very Interested

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- Very nice technique for quantifying spatial distribution of residual stress and nano-hardness of variously machined SiC. Would be interesting to see if there is a correlation of plastic work to polytype or stacking faults. Also, would be interested in work of various glasses at the highest possible resolution.
- Need to apply to ballistics as well as general mechanical testing. Also, need to include effect of adhesive chemistry – address question whether compressive surface stress is good, and whether stress should be uniform, and whether surface should be smooth.

#### Interested

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- How does this compare with xrd technique. I would also expect a reduction in stress with samples that are equal surface finish on both side as opposed to just one.
- Interested in continuing with different material set (not SiC). Will get back to Adrian/Rich with our preferred material sets for investigation by mid May.
- Future work >>> glass
- Would like to see this extended to other materials.

#### Interested with Change

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- should be extended to thin machined ceramic parts - Silicon Nitride parts 2/" x 2/" x 0.005/" thick - and relate to how machine to eliminate stress to maintain flatness

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (K) Non-Destructive Characterization of Dense Ceramics**

**Project PI: Rich Haber (Rutgers)**

Level of Interest	Level of Company Relevance
Very Interested - 2	High - 2
Interested - 5	Moderate - 4
Interested with Change - 0	Some - 2
Not Interested - 1	None - 0
Abstain - 0	

### **Very Interested**

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- Critical to continue to drive forward to understand in one material set what exactly the ultrasound maps mean in terms of microstructure and performance. Is it time to open up to other material sets beyond SiC and alumina. Open to discuss other material sets of interest with investigators.
- Anxious to learn more.

### **Interested**

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- Look at Quasar commercial unit for defect determination - go - no go determination  
This is the last paper I will be here for
- The NDE work is still evolving into a true material characterization technique.

## LIFE Form Review

### Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012

**Project: (L) Hydrothermal Purification of Refractory Oxides and Ceramic Precursors**  
**Project PI: Joe Kolis (Clemson)**

Level of Interest	Level of Company Relevance
Very Interested - 0	High - 0
Interested - 1	Moderate - 0
Interested with Change - 0	Some - 4
Not Interested - 5	None - 3
Abstain - 1	

#### Interested

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- Interesting but not useful to us.

#### Not Interested

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- Will check with diverse businesses to gauge interest in crystal growth outside of rare earth laser application materials
- Good complement to Riman/'s project
- Project needs a clear set of goals.

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (M) High Strength, High Modulus Inherently Flame Retardant Fibers via Wet Spinning**

**Project PI: Phil Brown (Clemson)**

Level of Interest	Level of Company Relevance
Very Interested - 0	High - 0
Interested - 1	Moderate - 1
Interested with Change - 0	Some - 2
Not Interested - 4	None - 3
Abstain - 1	

### **Not Interested**

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- Could be the beginning of a better armor(?) than kevlar, probably important, but not to my organization.



## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (N) Optically Active Fibers and Coatings**

**Project PI: John Ballato (Clemson)**

Level of Interest	Level of Company Relevance
Very Interested - 0	High - 0
Interested - 0	Moderate - 0
Interested with Change - 0	Some - 1
Not Interested - 5	None - 5
Abstain - 1	

### **Not Interested**

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- Cool!
- Very interesting work, unfortunately not relevant to our company.
- Pretty neat stuff; but not for our applications.

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (O) Towards Fibers That Will Posses Hydrophobic/Oleophobic Properties for an Extended Period of Time**

**Project PI: Igor Luzinov (Clemson)**

Level of Interest	Level of Company Relevance
Very Interested - 0	High - 0
Interested - 1	Moderate - 1
Interested with Change - 0	Some - 0
Not Interested - 3	None - 4
Abstain - 1	

## LIFE Form Review

**Ceramic, Composite & Optical Materials Center (Rutgers University) - April 26th, 2012**

**Project: (P) Directional Crystallization of the Mullite Fiber from the Polymeric  
Project PI: Fei Peng (Invited Speaker) (Clemson)**

Level of Interest	Level of Company Relevance
Very Interested - 1	High - 0
Interested - 3	Moderate - 1
Interested with Change - 0	Some - 3
Not Interested - 1	None - 2
Abstain - 1	

### **Very Interested**

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- Interesting to followup. Need to see if this is scaleable and cost considerations. We may be very interested in followup developments.

### **Interested**

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- Will have to solicit feedback from diverse business units to determine exact interest. Need to discuss what are planned next steps - or is this potentially up to members
- Electrospinning of ceramic fiber seems like a good fit for ccomc
- Little interest at this time with respect to my company/'s needs, but this looks useful and should be continued.

### **Not Interested**

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- I would like to see more work in ceramic fibers, this could be a real asset to the center.