5-24-2016

Using of spouted bed spray granulation process for fabricating of metal/ceramic-polymer composites

Eduard Eichner  
_Hamburg University of Technology, Institute of Solids Process Engineering and Particle Technology, Germany_,  
eduard.eichner@tuhh.de

V. Salikov  
_Hamburg University of Technology, Institute of Solids Process Engineering and Particle Technology, Germany_

M. Dosta  
_Hamburg University of Technology, Institute of Solids Process Engineering and Particle Technology, Germany_

S. Heinrich  
_Hamburg University of Technology, Institute of Solids Process Engineering and Particle Technology, Germany_

G.A. Schneider  
_Hamburg University of Technology, Institute of Advanced Ceramics, Germany_

Follow this and additional works at: [http://dc.engconfintl.org/fluidization_xv](http://dc.engconfintl.org/fluidization_xv)  
Part of the [Chemical Engineering Commons](http://dc.engconfintl.org/fluidization_xv)

**Recommended Citation**

http://dc.engconfintl.org/fluidization_xv/107

This Abstract and Presentation is brought to you for free and open access by the Proceedings at ECI Digital Archives. It has been accepted for inclusion in Fluidization XV by an authorized administrator of ECI Digital Archives. For more information, please contact franco@bepress.com.
Using dilute spouting for fabricating of highly filled metal-polymer composite materials

Eduard Eichner¹, Vitalij Salikov¹, Maksym Dosta¹, Stefan Heinrich¹, Gerold A. Schneider²

¹ Institute of Solids Process Engineering and Particle Technology
² Institute of Advanced Ceramics, Hamburg University of Technology
Introduction
Artificial vs. biological structural materials

**metals/alloys:**
- great mechanical properties
- energy-intensive production
- often high density
- electrically conducting

**ceramics:**
- hard, strong
- difficult to process
- brittle and sensitive to structural defects

**polymers:**
- ductile
- easy to process
- soft
Nacre

- Highly filled: 95 vol.-% mineral (ceramic)
- 5 vol.-% proteins (polymer)
- Platelets (high aspect ratio)
- Hierarchical structure

High fracture toughness
Strength: up to 120 MPa
Elastic modulus: 40-70 GPa


Research Center “Tailored Multiscale Materials Systems”
Aim: fabrication of bulk hierarchical materials
Coating of ceramic/copper-polymer composites

Process route

copper powder $d_p \approx 30\mu m$

copper-polymer granules

spouted bed coating

warm compaction at $T = 160^\circ C > T_g$
and high pressure 500, 750 MPa

metal-polymer composite

(bending bars)
Coating of ceramic-polymer composites
Spouted bed granulation

Spouted bed apparatus optimized for fine particles
Process chamber
Filter system
Pump

Particle movement in the process chamber
Nozzle

Particle formulation process
Coalescence
Solidification
Agglomeration
Growth
Growing solidification of liquid film
Enlarged granules
Drying
Evaporation

Spraying
Solution droplets
Granules
Wetting
Liquid film

www.tuhh.de/spe
Good insulator properties of metal polymer composites
These results reveal that particles are uniformly coated (separated from each other by polymer and screened)
In spite of 78 vol.% of copper composites are insulator ($10^5 \, \Omega m$)
Good relative permittivity of copper-polymer composites
The relative permittivity on high metal contents above 200

\[ C = \varepsilon_0 \varepsilon_r \frac{A}{d} \]

- \( C \) capacitance [F]
- \( \varepsilon_0 \) electric constant \( 8.854 \times 10^{-12} \) F·m\(^{-1}\)
- \( \varepsilon_r \) relative permittivity [ ]
- \( A \) cross section area of electrode plates [m\(^2\)]
- \( d \) distance between plates [m]

Frequency 1 kHz

Relative permittivity

Cu amount [vol.%]
**Design parameter aspect ratio**  
**Current research**

**Aspect ratio**: \( \rho = \frac{L}{h} \)

\[
\frac{1}{E} = \frac{4(1 - \Phi)}{G_m \Phi^2 \rho^2} + \frac{1}{\Phi E_p} \rightarrow E \propto G_m \rho^2
\]

Large aspect ratio of mineral crystals can compensate softness of matrix

\[
S = \min \left( \frac{\Phi \rho S_m}{2}, \frac{\Phi S_p}{2} \right)
\]

Optimal design of composite materials: \( S_p = S_{int} = S_m / \rho \)

\( G_m \): shear modulus of matrix  \( \Phi \): volume fraction of particles  \( E \): Young’s modulus  
\( S_m \): strength of matrix  \( S_p \): tensile strength of particles  
\( S_{int} \): strength of interface

Deformation of copper-polymer agglomerates
Extension of process route by rolling

spouted bed coating

copper-polymer granules

warm compaction at $T > T_g$ and high pressure

rolling mill

rolled copper-polymer granules
Enhancement of mechanical properties of copper-polymer composites by increasing of aspect ratio of particles
Summary and outlook

Summary

• fabricating of copper-polymer composites with **high resistivity**
• **high permittivity** of copper-polymer composites
• development of new process route for studying of aspect ratio
• improvement of mechanical properties by rolling (higher aspect ratios)

Outlook

• use of coarser metal particles for higher aspect ratios
• use high-performance polymers (high shear modulus)
• improvement of particle-polymer interface
Thank you for attention!

www.tuhh.de/sfb986