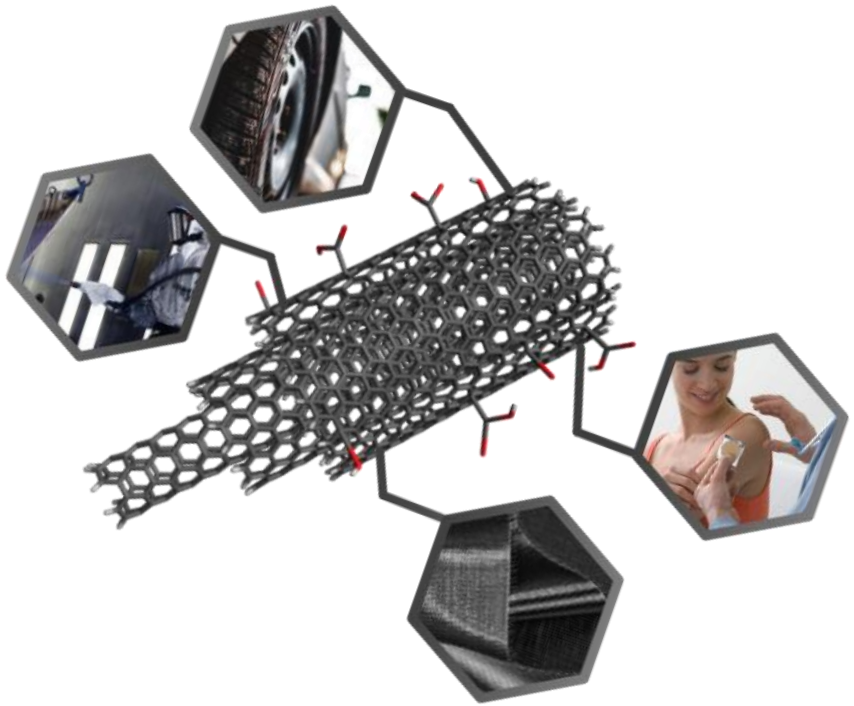
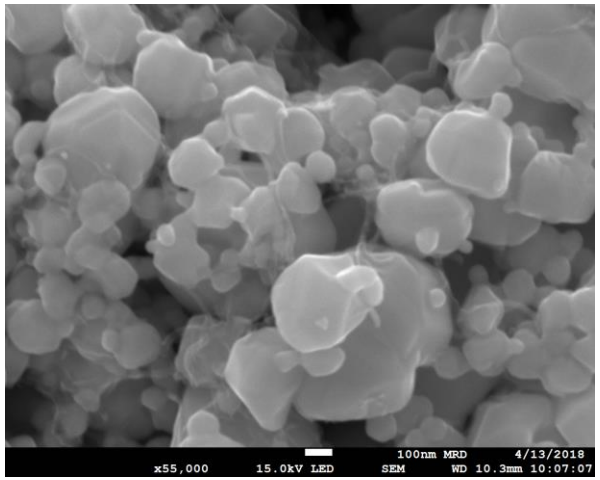
# MOLECULAR REBAR®

*Nano-solutions for Conducting Inks*



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MOLECULAR REBAR® DESIGN

*Transforming Businesses with Nanotechnology*

# Advanced nanotechnology for new and existing markets

- **Molecular Rebar®** is an advanced carbon nanotube additive tailored to disperse easily at the nanoscale in a wide range of conductive inks.
  - Silver
  - Copper
  - Carbon
- Molecular Rebar® takes ink formulations to the next level of rugged performance in a range of applications: ***wearables, smart clothing, flexible circuitry, and bendable optics.***

# Challenges for conductive silver inks

## Growing markets

- Improved resistance to cracking on bending or stretching
- Improved print resolution
- Increasing the range of substrates, plastics to fabrics

## Cost reduction

- Improved print speed
- Lower temperature curing
- Thinner traces for the same conductivity
- Improved print quality – less rejects

**Molecular Rebar® is uniquely tailored to meet these needs**

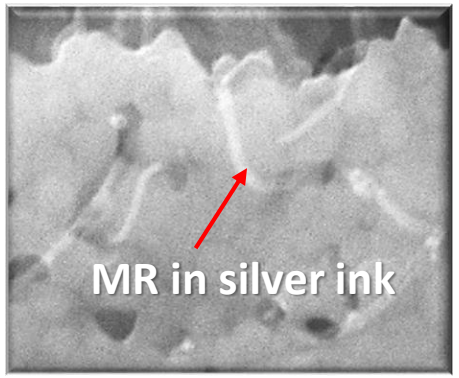
# MOLECULAR REBAR® for Conducting Inks

## Benefits of MR for Conducting Inks

4

| Improved Printing | Improved Fusion | Improved Adhesion | Improved Strength and Flexibility | Easy Implementation | Storage Stable |
|---|---|---|---|---|---|

- Tailored solutions to meet your needs
- Is0 9001  certified manufacturing
- World class technical support & laboratories

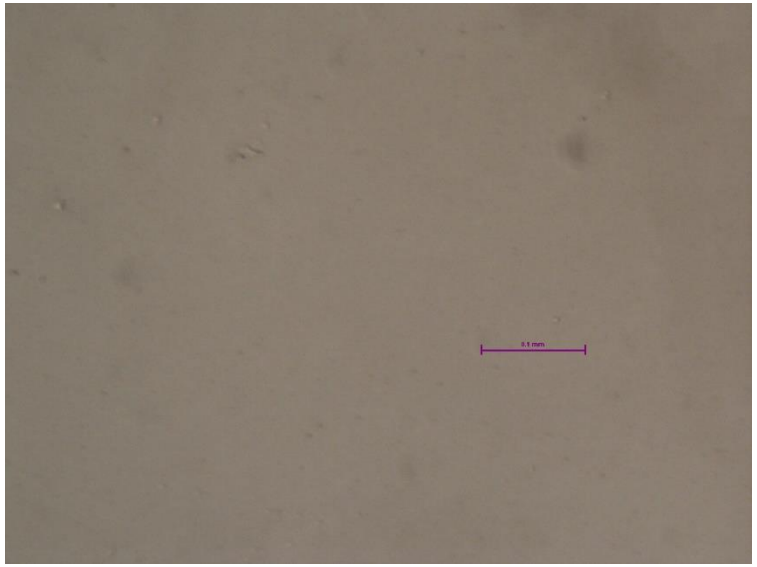



# Excellent dispersions of Molecular Rebar – no print head clogging even at high MR loadings

Easy mixing of MR with ink

Optical Microscopy at 175X

Silver ink + 0.5% wt MR

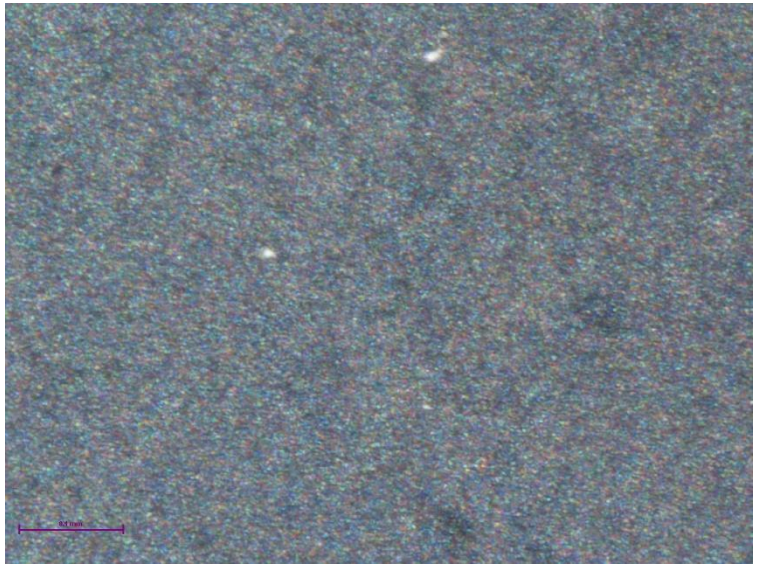


Excellent dispersion of MR in ink

**No MR particles > 1 micron**

Very uniform film

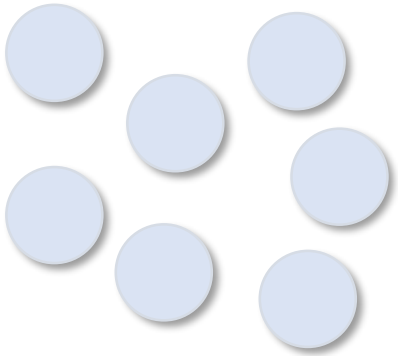
Dried Silver film + 0.5% wt MR



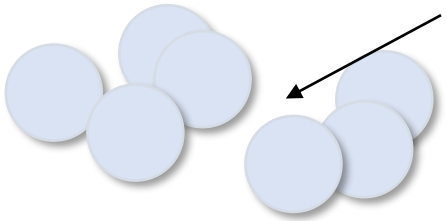
The wt. % MR is relative to the solids content
The film was sintered at 120 °C, 15 minutes.

# How MR improves performance of conductive inks

Ink particles in solution

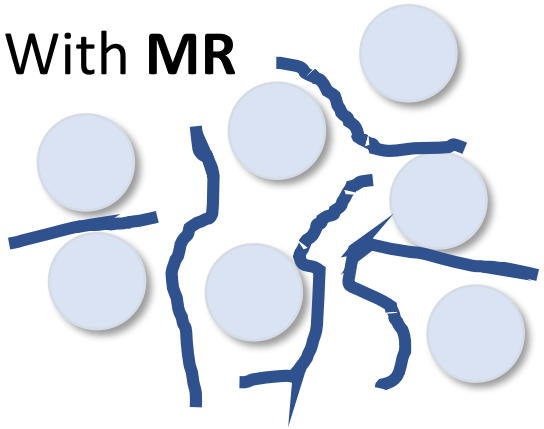


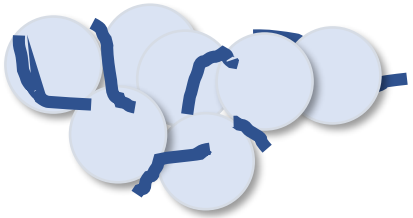
Ink particles after sintering



Cracks or voids in the film

With **MR**

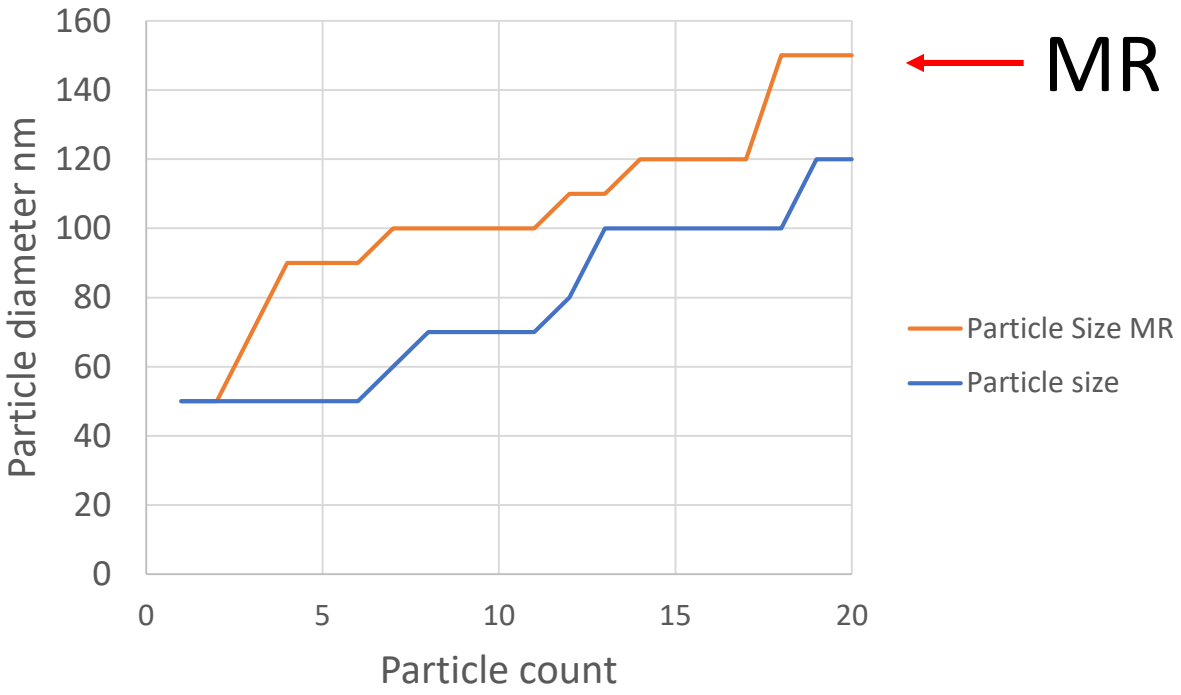




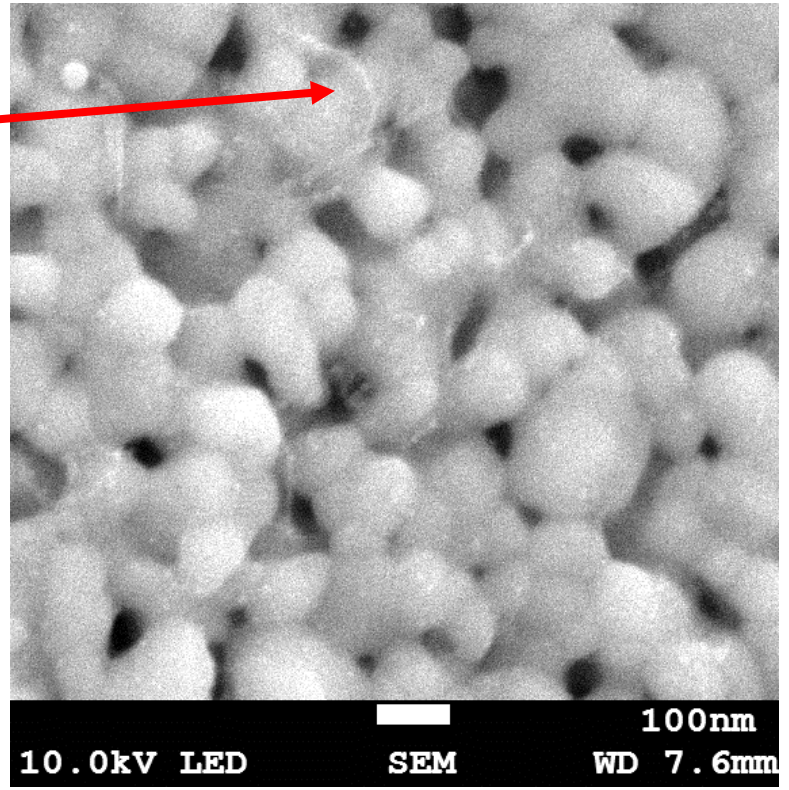
Particles held together with **MR** during & after sintering
More effective heat transfer

# Observations on enhanced sintering with MR

- Digital silver nano-inks




MR



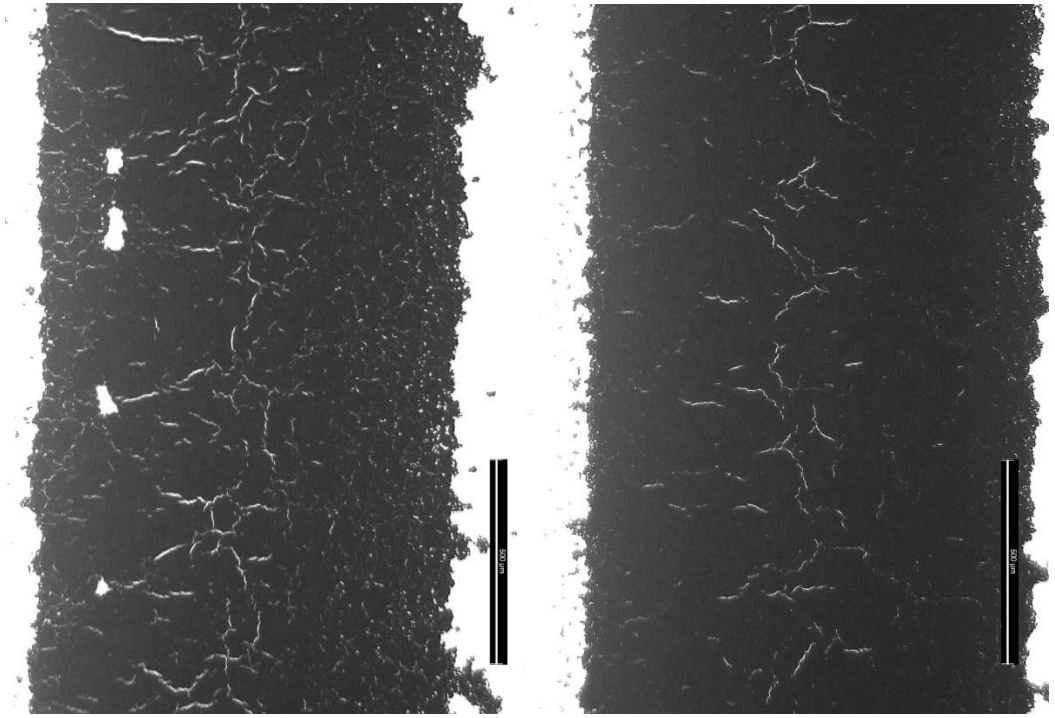

MR leads to improved conductivity

# Improved digital printing with MR on fabrics

Conductivity measured on 100mmx1mm lines

No MR

**0.25% wt. MR**

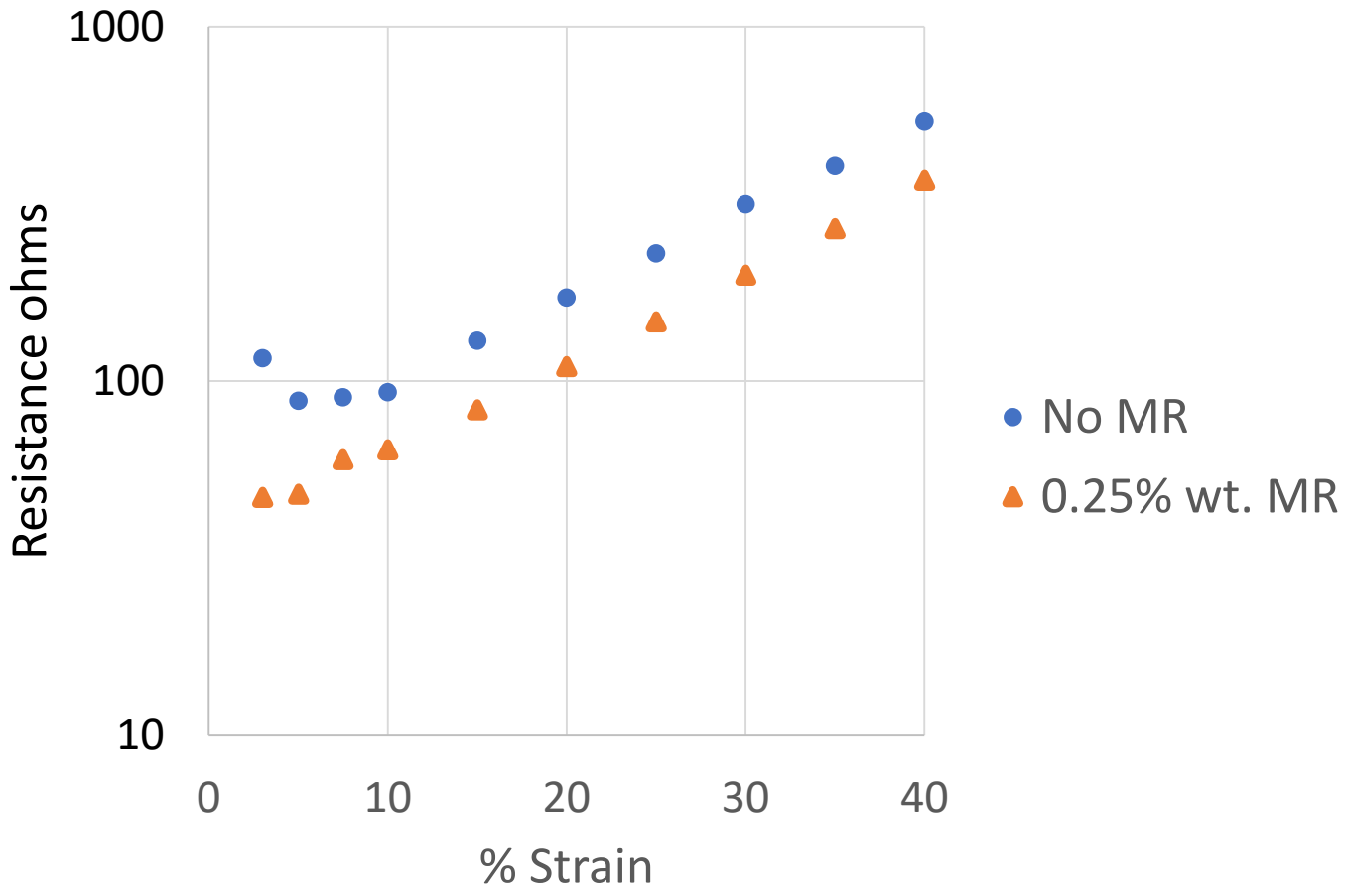


Average resistance
34 ±4.6 ohms

Average Resistance
25.5 ±2.2 ohms

- MR improves resistance to cracking on rapid printing with significantly improved conductivity
- MR is even more effective with flash sintering
  - Strong absorption of energy from near IR to Tera-Hertz frequencies – a black hole!

# MR for flexible substrates




Silver ink with 0.25% wt. MR kept its improved conductivity while stretching up to 40% on stretchable fabric

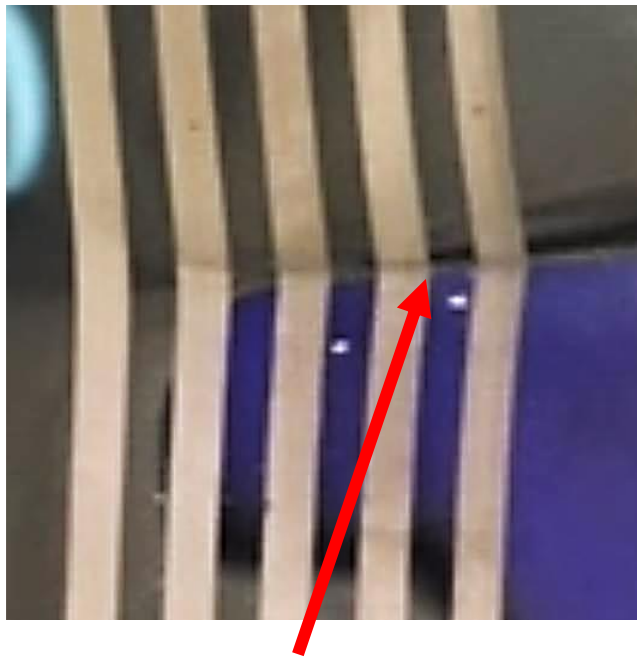
# MR improves retention of conductivity with creasing

Printed on ST505 film with a UV-digital print head, then creased

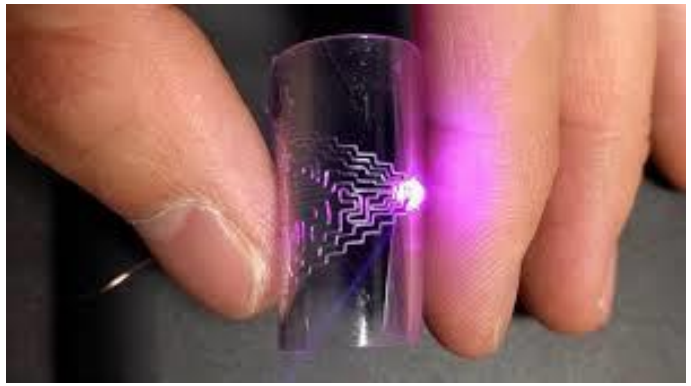
Silver digital ink, no MR

Flaking & Fracture
No conductivity

Silver digital ink, 0.16% wt MR



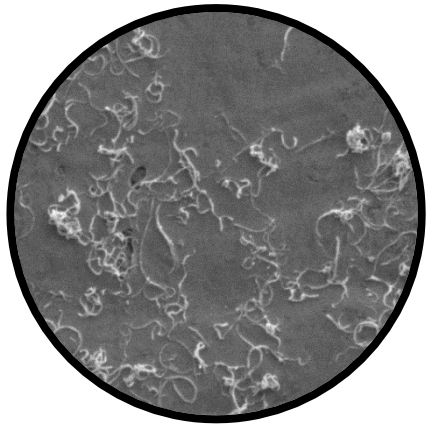
**With MR Conductivity maintained**



MR improves reliability under continuous flexing

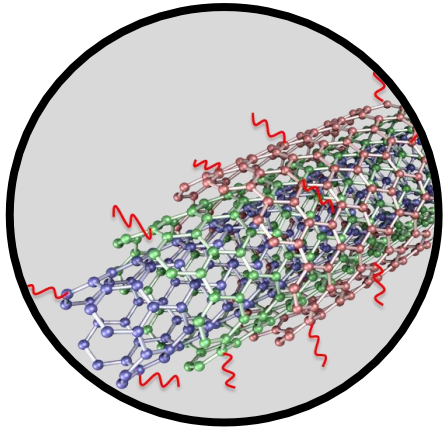
# MOLECULAR REBAR® Technology

**Detangled, Individualized & Purified multiwall carbon nanotubes**



- *Very Low impurity level*
- *Drop-in addition*
- *Sub-micron level flow*
- *13nm dia. x 900nm length*

**Functionalized**



- *Designed for enhanced interaction with inks and substrates*
- *Excellent shelf life*

**Dispersed**

- *System Compatibility*
- *Easy to implement*
- *Safer for Handling*

Available in organic and aqueous media

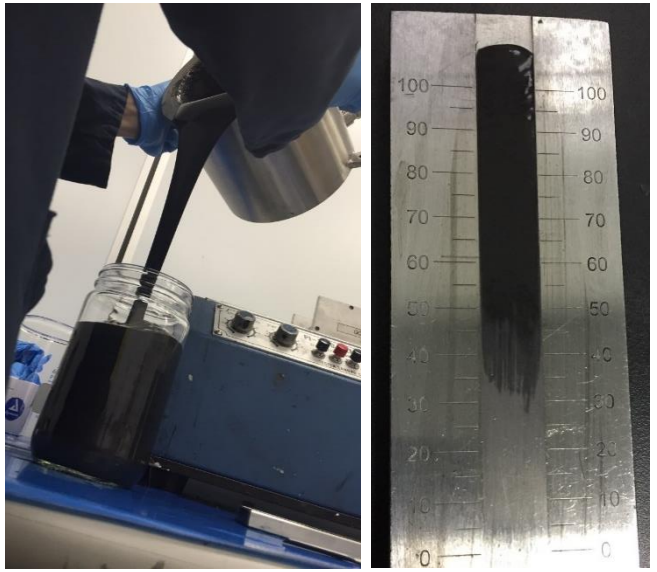
# Simple to use… Easy to implement…Enhanced formulation

Available as 2-12% weight Molecular Rebar concentrates

**Easy to Mix**

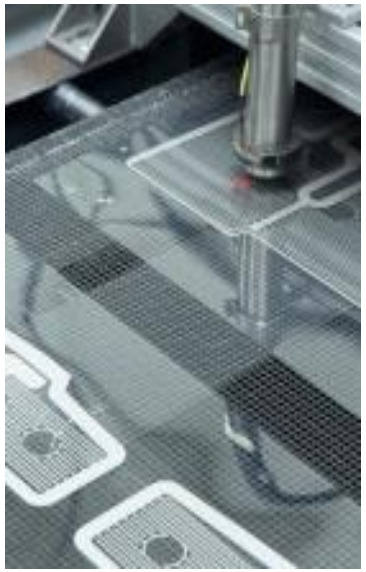

- ***No change in equipment***
- ***Very simple mixing process***

**Excellent ink Property**




- ***Excellent ink quality***
- ***Good ink shelf life***
- ***Easy filtration***

**Smooth Printing**



- ***Standard coating conditions***
- ***No cracking or spots***

# Growing Markets that MR can enhance

- Conductive inks, Inkjet, aerosol, flexographic or screen.
  - Increased durability, increased flexibility
  - Improved flash sintering – faster processing
- Conductive adhesives
  - Stronger, more durable
- Thick Film Technology
  - Applicable to gold, silver, copper, palladium, etc.
  - Controlled rheology, Improved form factor capability
- Passive component pastes
  - Increased green strength for plate transfer
- Thick print copper
  - Controlled rheology
  - Use of nanoparticles for low sintering temperatures
- Ceramics
  - Improved green strength, nano-porosity for high temperature ceramics

# MR technology fits with many materials.

- Graphite
- Graphene
- Carbon black
- Copper
- Zinc
- Silver

- Lead oxide
- Titanium dioxide
- Silica
- Silicon
- Lithium salts
- Calcium hydroxyapatite
- Magnetic nanoparticles

- Water
- Aqueous alcohols
- Alcohols
- Ethylene glycol types
- Pyrrolidones
- Aryl-alcohols
- Alkyl carbonates
- Terpineols
- Polyols
- Epoxies
- Urethane acrylates

# How can we help you?

- Molecular Rebar Design has extensive laboratory capabilities and nanotechnology expertise and experience with customers to help get the best performance and economics from your existing or new formulations.

- Recommended steps to success:
  1. Discussion of targeted goals and limitations
  2. Initial joint assessment of formulations
  3. MRD support for customer evaluations
  4. MRD support for commercial implementation

MRD's Nano-Technology experts will work with you to create success

# Contact us

We hope to have excited you with the new possibilities for commercial success in conducting inks with Molecular Rebar® and welcome the opportunity to hear from you how we could bring enhanced sales and performance to you and your customers

www.molecularrebar.com

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# Who we are. Molecular Rebar Design LLC

- Established 2009, Austin, Texas, to develop a breakthrough form of discrete, surface modified multiwall carbon nanotubes (MWCNT's), called MOLECULAR REBAR®.
- Rapid growth via partnerships (licensing & partial ownership)


Energy Storage (Lead Acid & Lithium Batteries)

- **Peak Nano:** Defense/Military applications
- **Biopact Ventures: T**argeted biomolecule delivery into cells
- **MECHnano:** Additive manufacturing (3D printing)
- Durable Rubbers & Elastomers
- Corrosion Resistant Coatings

***And now conducting inks***

# Molecular Rebar Design LLC

- **We are at a business development stage for our unique technology in this field of conducting inks and seeking partners to accelerate market entry of MR**

- Molecular Rebar Design is the *only* commercial large scale manufacturer of individual multiwall carbon nanotubes surface tailored for enhanced performance conductive inks

- Protected IP by 74 granted patents globally

- Extensive R&D facilities and in-depth knowledge base in mixing & coatings leveraged from existing business technologies