



Rubber&Plastics News



**Welcome to the International Silicone Conference**

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# APPLIED CURIOSITY

## Third Stream Additives that Modify LSR and HCR

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Curiosity is at the root of nearly every business decision and strategic action we take. It's how we approach...

- Every technical inquiry
- Every sales opportunity
- And it's modeled in our genuine desire to serve our customers efficiently and effectively.





# About NovationSi: Overview

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**NovationSi** is a materials science company specializing in high quality modifiers, additives, and colorants for LSR and HCR.

Specializing in “idea-to-execution” solutions for silicone rubber technologies.



# About NovationSi: Products and Services:

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## **NovaSpense® Dispersions:**

High quality colorants and additives, expertly dispersed for LSR, HCR, and RTV applications

## **NovaSpense® Modifiers:**

3rd stream additives and custom modifiers for LSR and HCR that address current industry needs (e.g., anti-static, antimicrobial, anti-fungal, and electro-conductive technologies...)



# Today's Curiosity is...

## NovaSperser<sup>®</sup> Modifier Technology for LSR and HCR

- Modifiers that Inhibit Microbial Growth
- Modifiers that Change Surface Properties

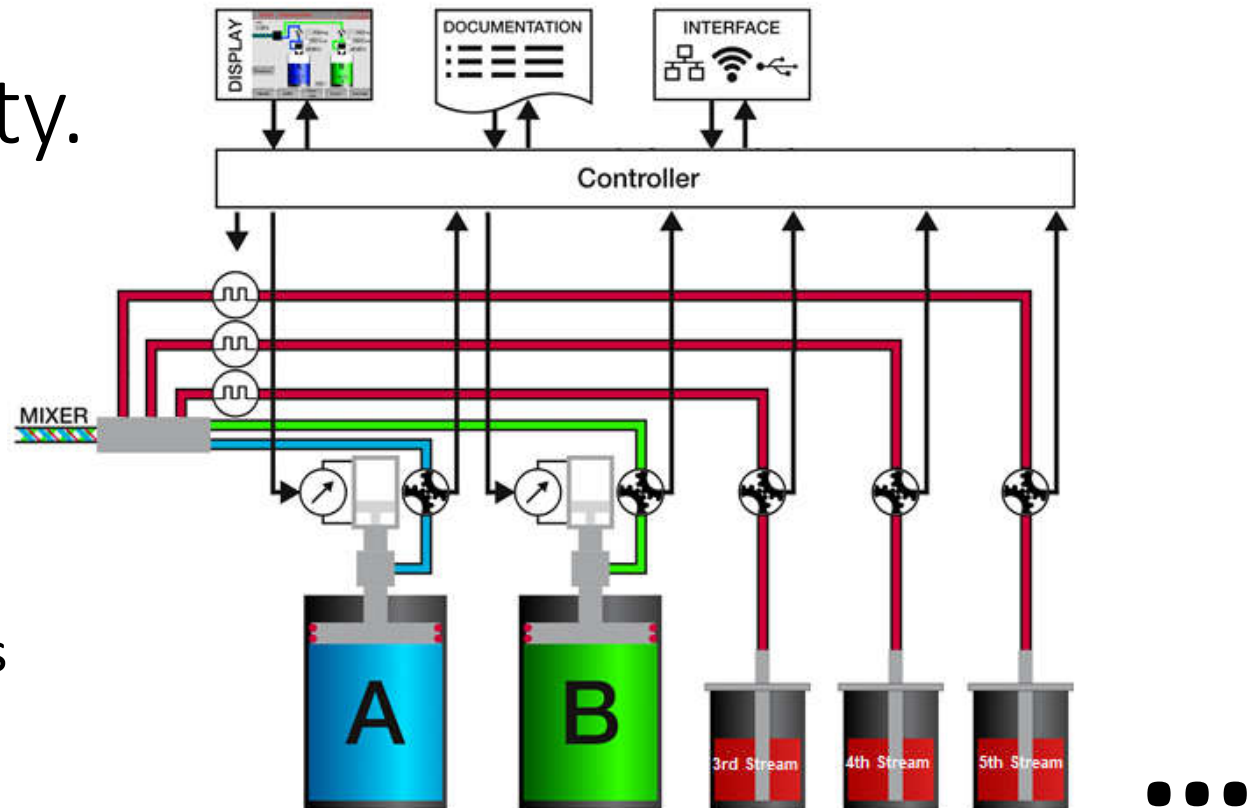
## Case Study: Essential Tremor Medical Device

- New! Nanotechnology for Wearable Medical Devices



# Modern LSR Pumping Capability.

- LSR Pumps have entered a new generation of performance
- ELMET TOP 5000 Pump: 0.3 to 10% with  $\pm 0.01\%$  Accuracy.
- This allows for considerations in modification of LSR Properties.



Used by permission from Elmet North America Inc.

# Modifiers That Inhibit Microbial Growth

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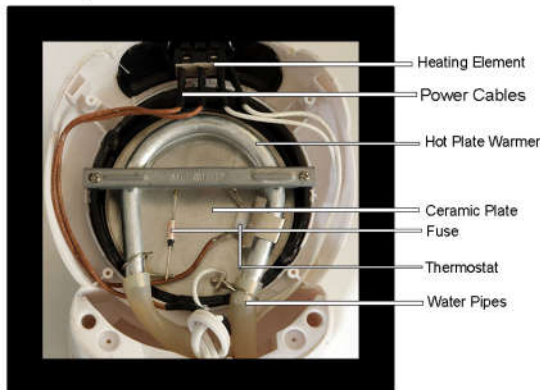


# Applications and Uses - Antimicrobial



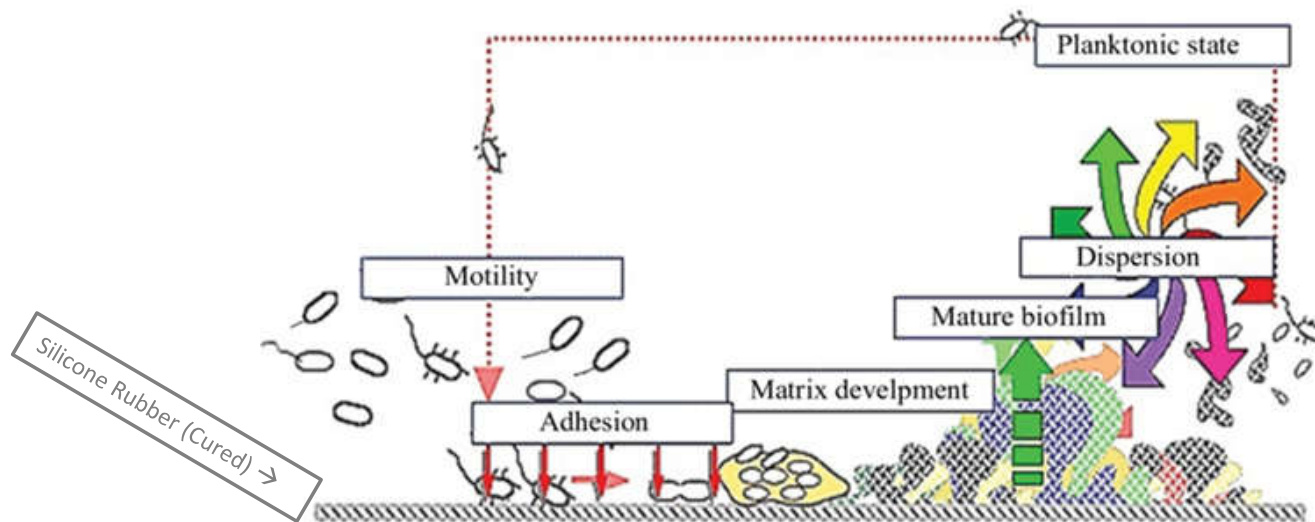
- Human Contact Applications
  - Personal care
    - PPE – Personal Protective Equipment: Masks, eyewear, shields, drapes, covers and shielding.
    - Healthcare materials for hospitals, clinics, and care facilities: Trays, beds construction, incontinence aids, plugs, electrical cords and tubing.
  - Wearable devices
    - Medical devices for diagnosis and therapy, wrist bands, workout devices, eye/sunglasses and dental implements.
- Consumer Applications
  - Potable water systems.
    - Water supply for RV, van, well systems, seals for faucet and shower heads.
  - Kitchen Appliance
    - Hoses and seals: coffee makers, dish washers and clothes machines.

Drip Coffee Maker Bottom



# Silicones by Nature Are:

- Not antimicrobial...
- Neutral in Microbial Resistance:
  - Si-O backbone of silicone does not provide nutrition.
- Biofilm Supportive:
  - Silicones do provide a platform that aids in microbial spread.



Shakibaie MR (2018) Bacterial Biofilm and its Clinical Implications. Ann Microbiol Res 2(1):45-50

## Strange Creatures...

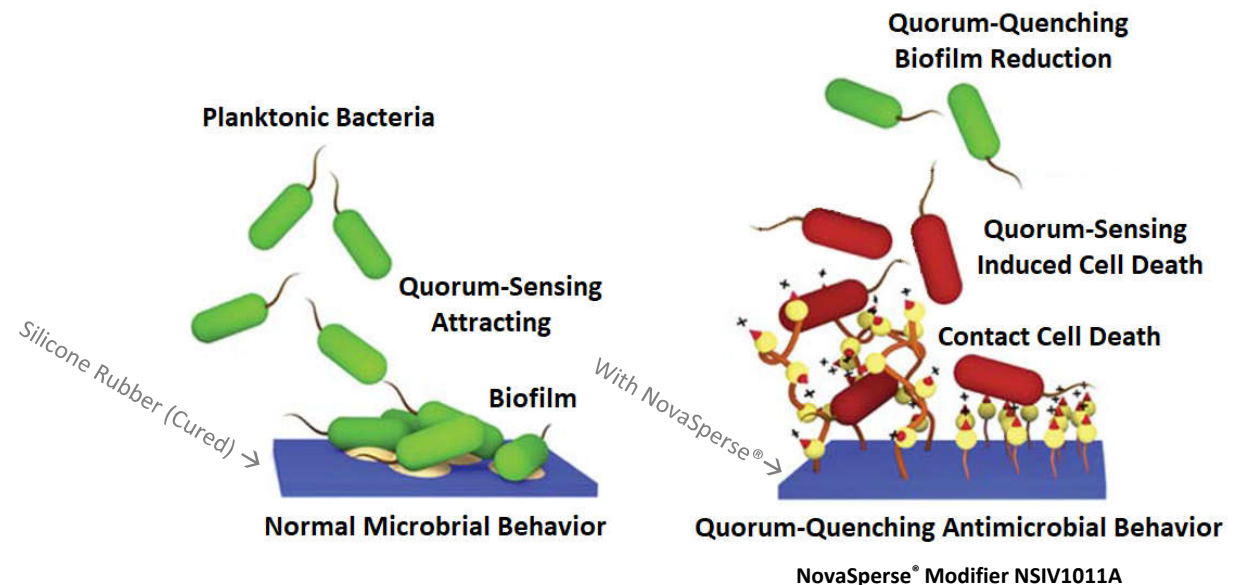
An antimicrobial containing elastomer possess a reducing spectrum of antimicrobial chemistries tied into the polymer. These are observable at the surface of the elastomer but do not leach or extract from the polymer in appreciable concentrations.

When a microbial colony is exposed to the antimicrobial surface, cell death is not limited to the bottom of the biofilm.

This phenomenon may be explained by the ability of planktonic bacteria or fungal hyphae to undergo quorum-sensing induced cell death in response to environmental stresses caused by the reducing spectrum.

## Antimicrobial Behavior in Quorum Quenching

“green” – live  
“red” – dead



Jiao Y, et al. Quaternary ammonium-based biomedical materials: State-of-the-art, toxicological aspects and antimicrobial resistance. Prog Polym Sci (2017), <http://dx.doi.org/10.1016/j.progpolymsci.2017.03.001>

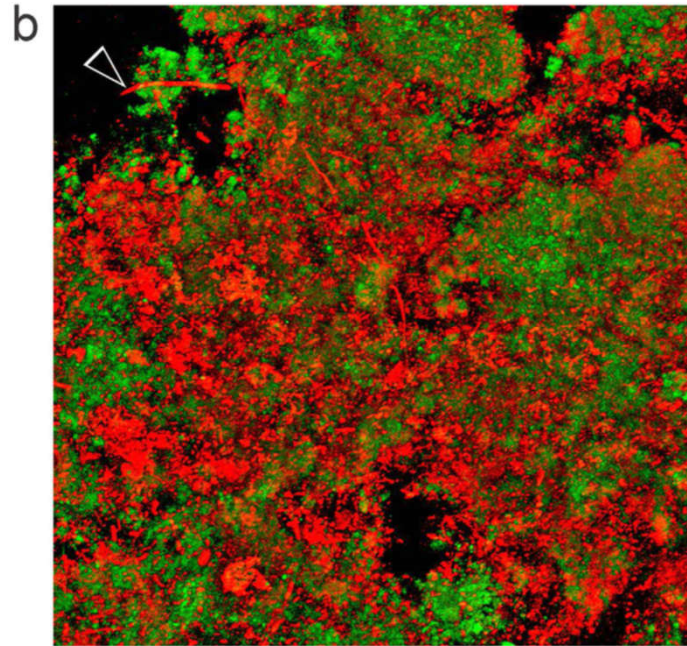
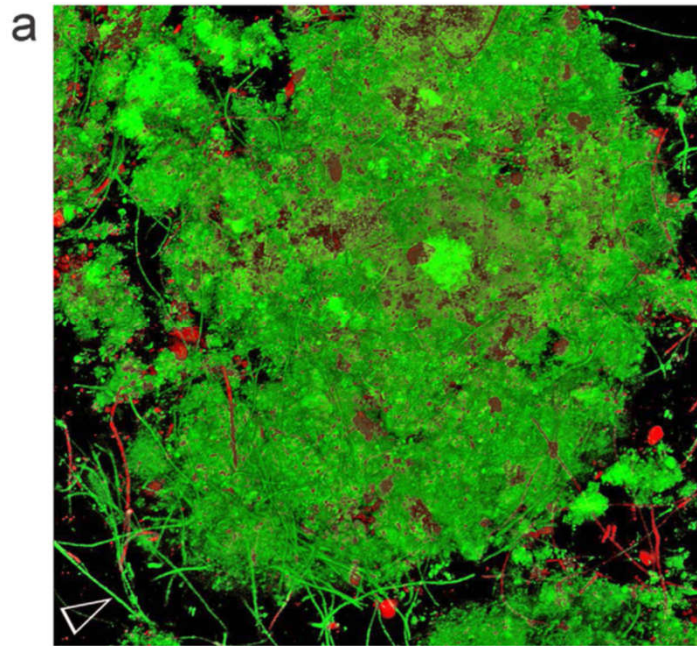


# NovaSperse<sup>®</sup> Modifier Performance

Confocal Laser Scanning Microscopy

“green” – live

“red” – dead



Surface

“a” = Control Polymer

“b” = 5% **NovaSperse<sup>®</sup>**

Bacteria and fungal hyphae suppression

## Straight Talk...

### Advantages:

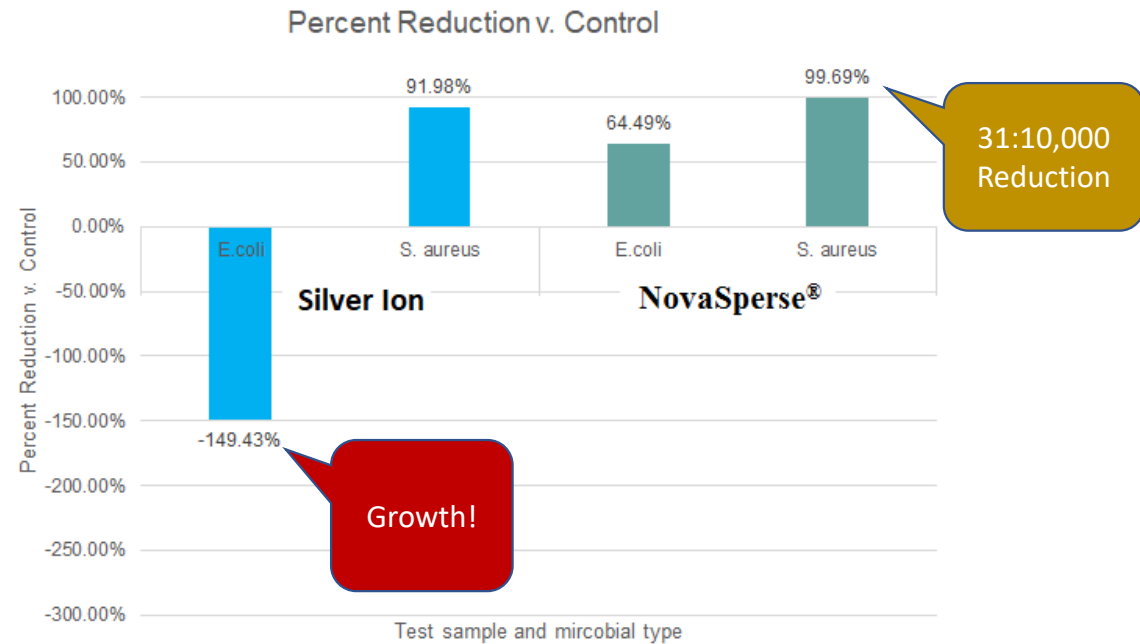
- Broad-spectrum performance
- Reduced extractability
- Wear or damage does not erode performance
- Human Contact per Req 21 CFR 872.3260 CLII 510K#:K190271

### Limitations:

- Service Temperature to 150°C.

## NovaSperser<sup>®</sup> Modifier Performance

Compared to Silver Ion (1wt% effective)



NovaSperser<sup>®</sup> Modifier NSIV1011A





# Modifiers That Change Surface Properties

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# Applications and Uses – Surface Modification

- Surface Slip Applications

- Electrical connectors
  - Automotive and Aerospace Applications
- Wearable devices (slip against skin)
  - Flexible Sensors: bands, straps, and caps
- Mechanical Devices (slip against substrates)
  - Kitchen Appliance – Rotation and sliding seals.

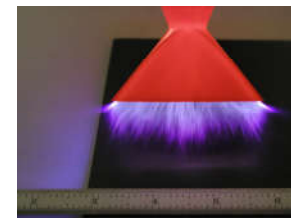
- Electro-Modification Applications

- Automated Processes
  - Clean Surface Injection Molding
    - Stop hang-up in demolding and cling onto surfaces.
  - Silicone Automated Assembly
    - Parts separate and stop clinging together
- Electromagnetic Interference (EMI)
  - Tapes, Caps and Extrusions



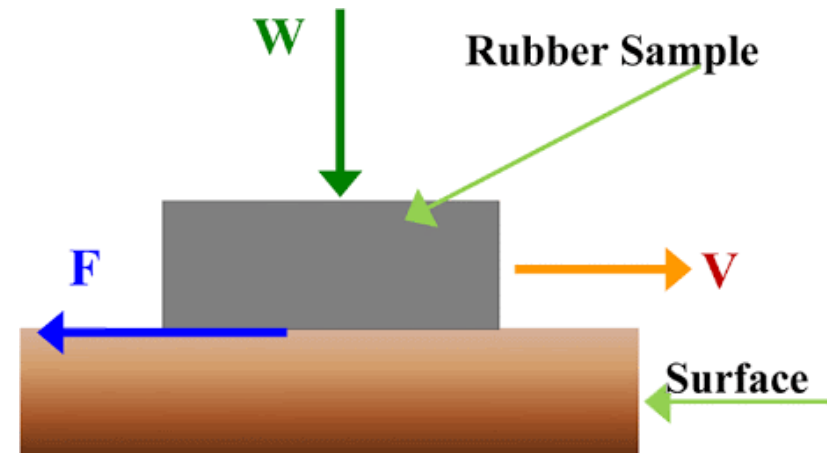
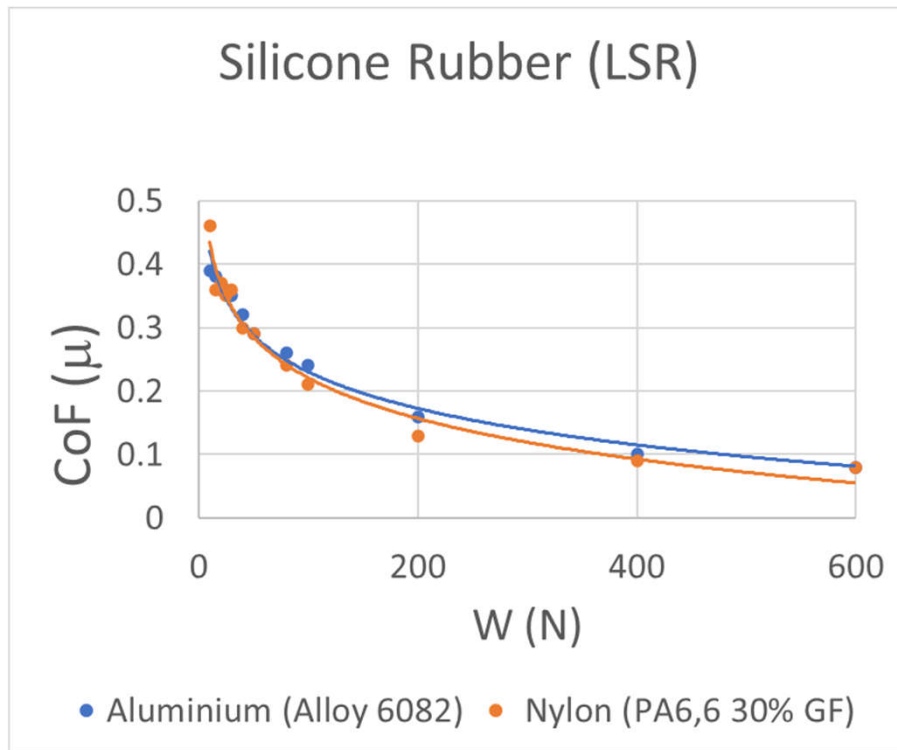
# Silicone Surface Modification Methods

- Surface Texturing
  - Known to reduce CoF by as much as 40%
  - Rough (prismatic) – Noticeable Reduction
- Self-Lubrication Additives
  - Known to reduce CoF by as much as 80%
  - Improves slip and electrical surface properties
- ~~Argon/Air Plasma Treatment~~
  - Known to reduce CoF by as much as 60%
  - Long treatment times – several sec./part
- Coatings
  - Known to reduce CoF by as much as 80%
  - Physical Vapor Deposition – Polymers (hard/soft)
  - Costly!



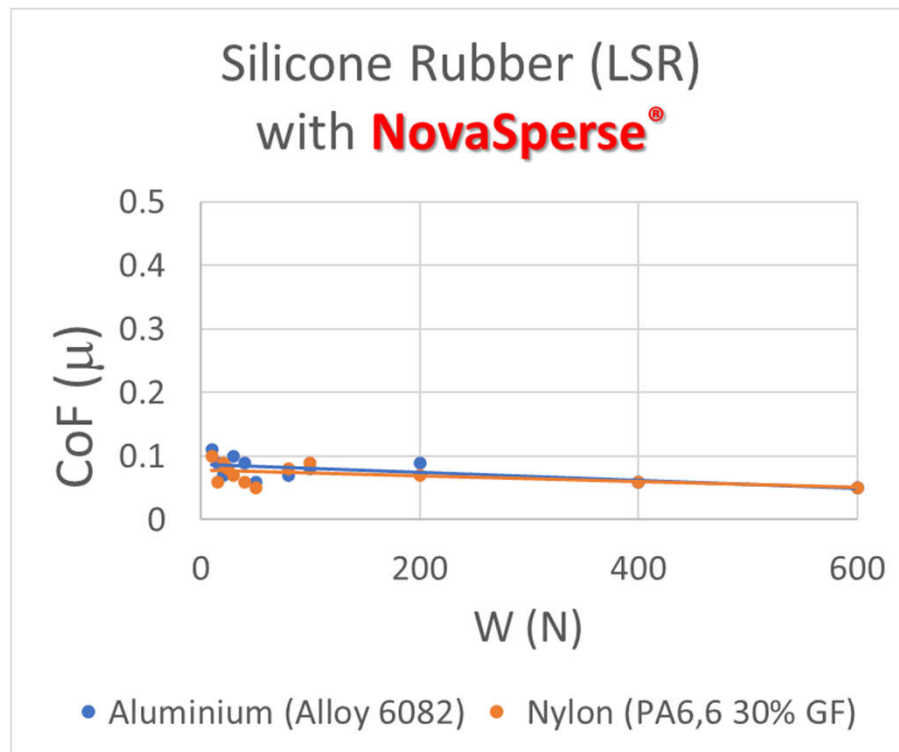
# Silicone Surface Modification - Self lubrication

- Dynamic Surface Friction – Coefficient of Friction
  - $\text{CoF } (\mu) = \text{ratio of the frictional force } (F) \text{ and load weight } (W) \text{ of an object against a surface}$

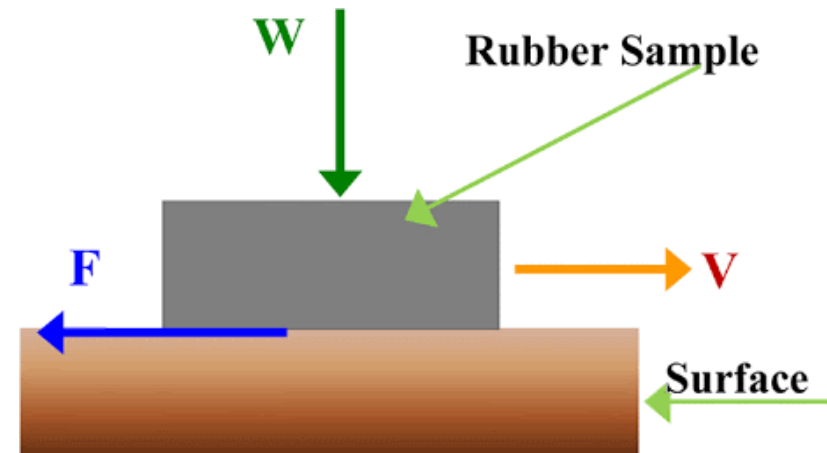


# Silicone Surface Modification - Self lubrication

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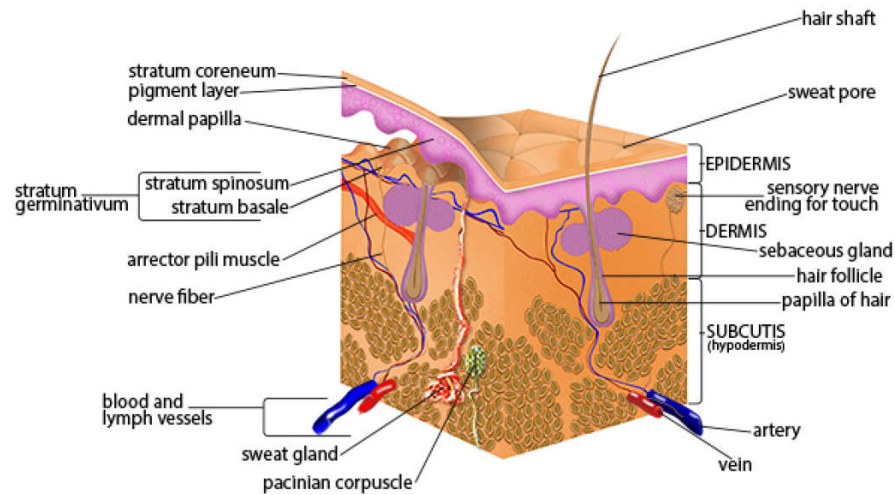


NovaSpers<sup>®</sup> Modifier NSIV1014A in combination with "rough"  
(prismatic) surface texturing of the mold.





# Silicone Surface Modification - Self lubrication



Material	Dynamic CoF
Silicone Rubber	.49 - .66
With NovaSpers®	.21 - .46 <sup>^</sup>
Silk (fabric)	.19 - .38
Polyamide (Nylon woven)	.29 - .45
Polyester (woven)	.40 - .52
Cotton (sock)	.46 - .48
Fine Wool Knit	.30 - .36

**"Silky"  
Feel**



**NovaSpers® Modifier NS101101A**

<sup>^</sup> Burnett et. al., "Cocos nucifera and related ingredients", CIR, International Journal of Toxicology, 30(Suppl. 1:15-16 (2011).

\* Luis Vilhena et. al, "Friction of Human Skin Against Different Fabrics for Medical Use", CEMUC, Department of Mechanical Eng, Journal of Lubricants doi 10.3390 (2016).

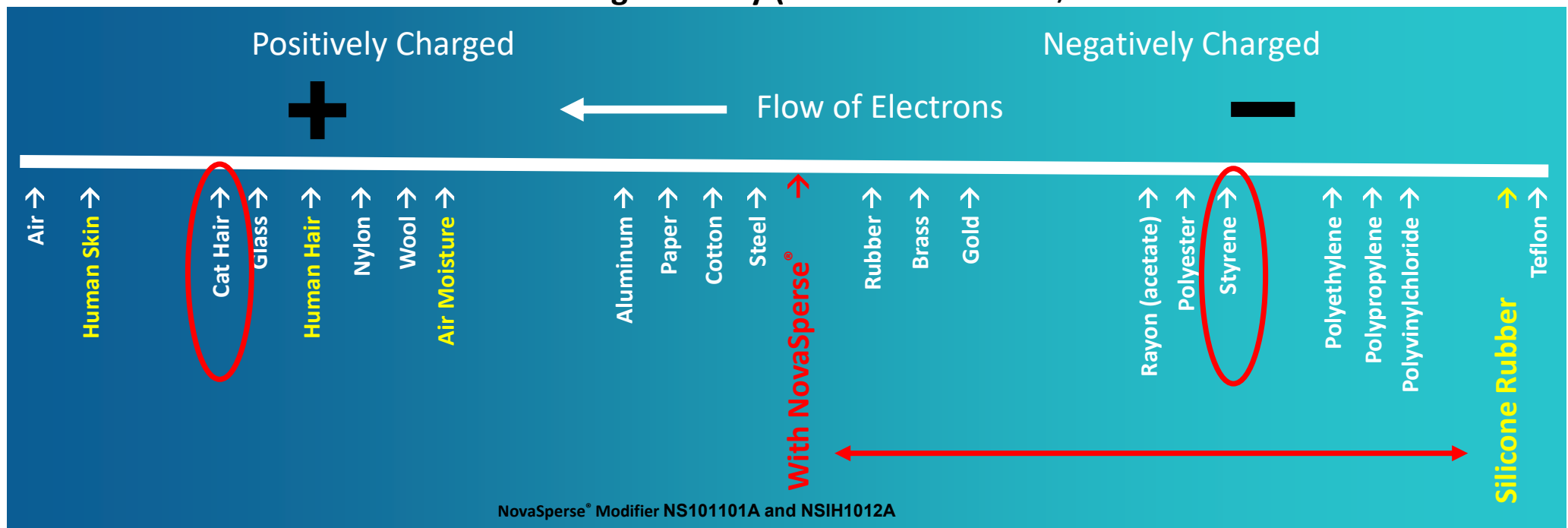
<sup>†</sup> Zhang M, Mak AF. In vivo friction properties of human skin. *Prosthet Orthot Int.* 1999;23(2):135-141. doi:10.3109/03093649909071625



# Silicone Surface Modification - Antistatic

- NovaSperser<sup>®</sup> Modifier Technology
  - Triboelectricity (Triboelectric Effect)
  - Charges are either negative or positive
  - Oppositely charged things tend to be attracted to one another and cause “Shocks!”

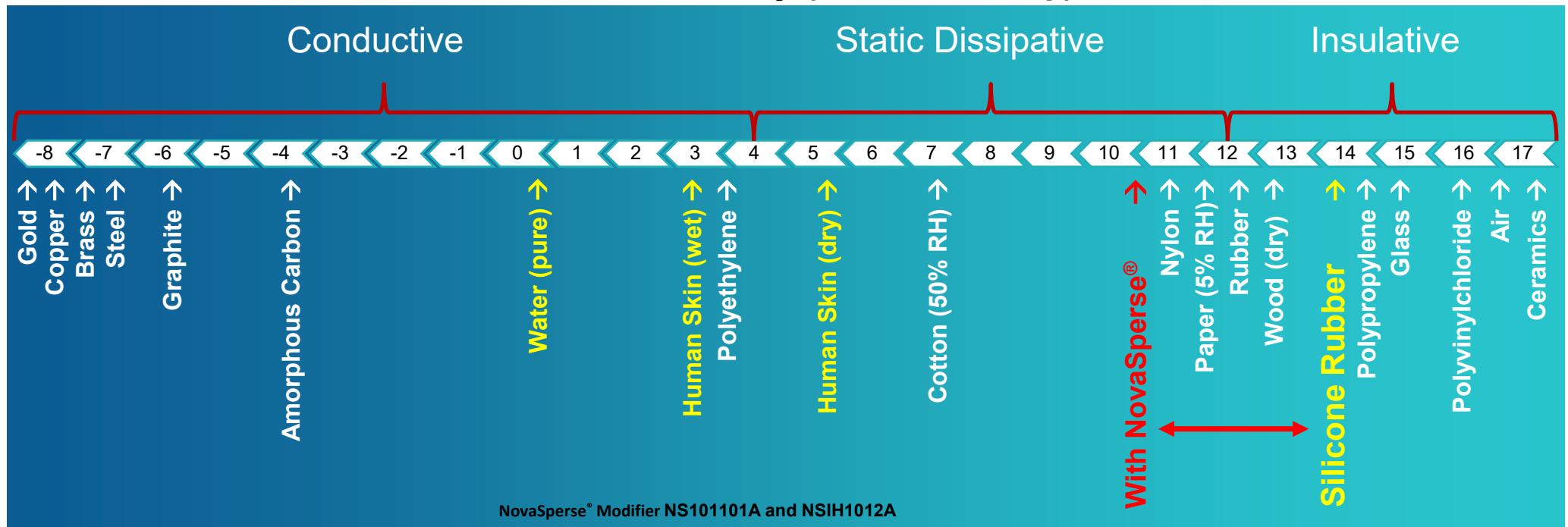
## Triboelectric Charge Density (tribo = Greek for “friction”)



# Silicone Surface Modification - Antistatic

- NovaSperser<sup>®</sup> Modifier Technology
  - Triboelectricity creates the charge
  - Silicones inherently have  $1.0 \times 10^{14}$  ohms/square surface resistivity (ANSI/ESD S541).
  - This high electrical resistivity holds onto charges – Silicones are Insulative

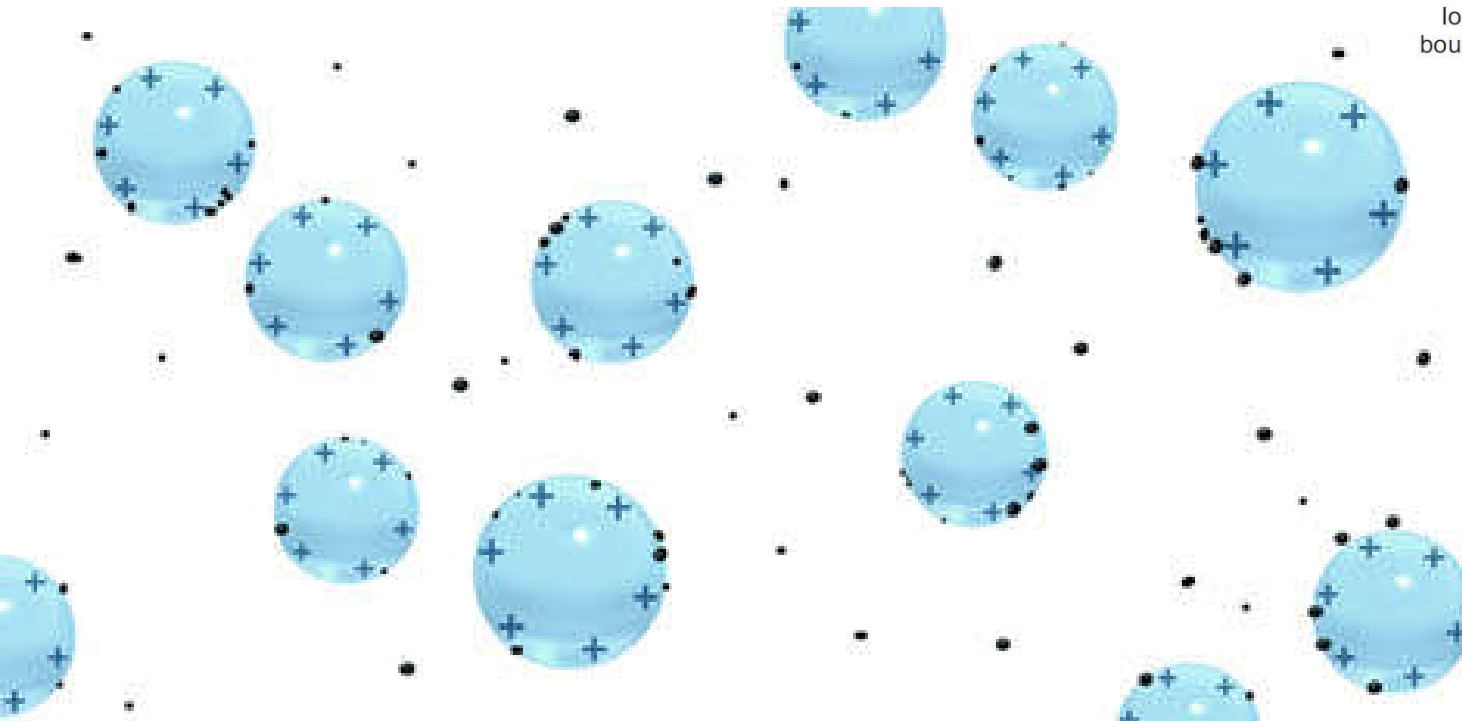
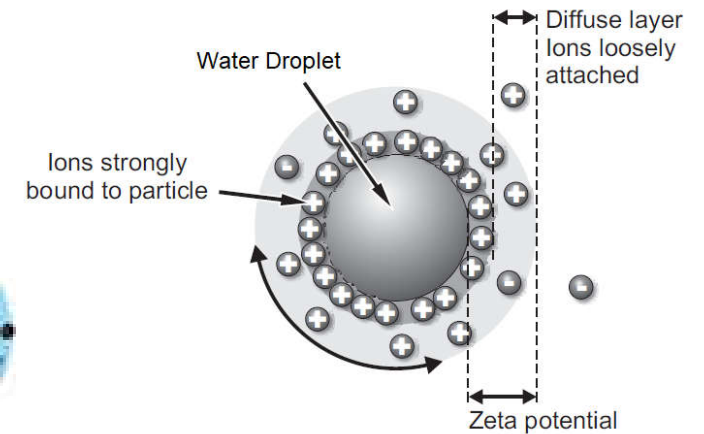
Surface Resistivity ( $10^X$  Ohms/sq.) →



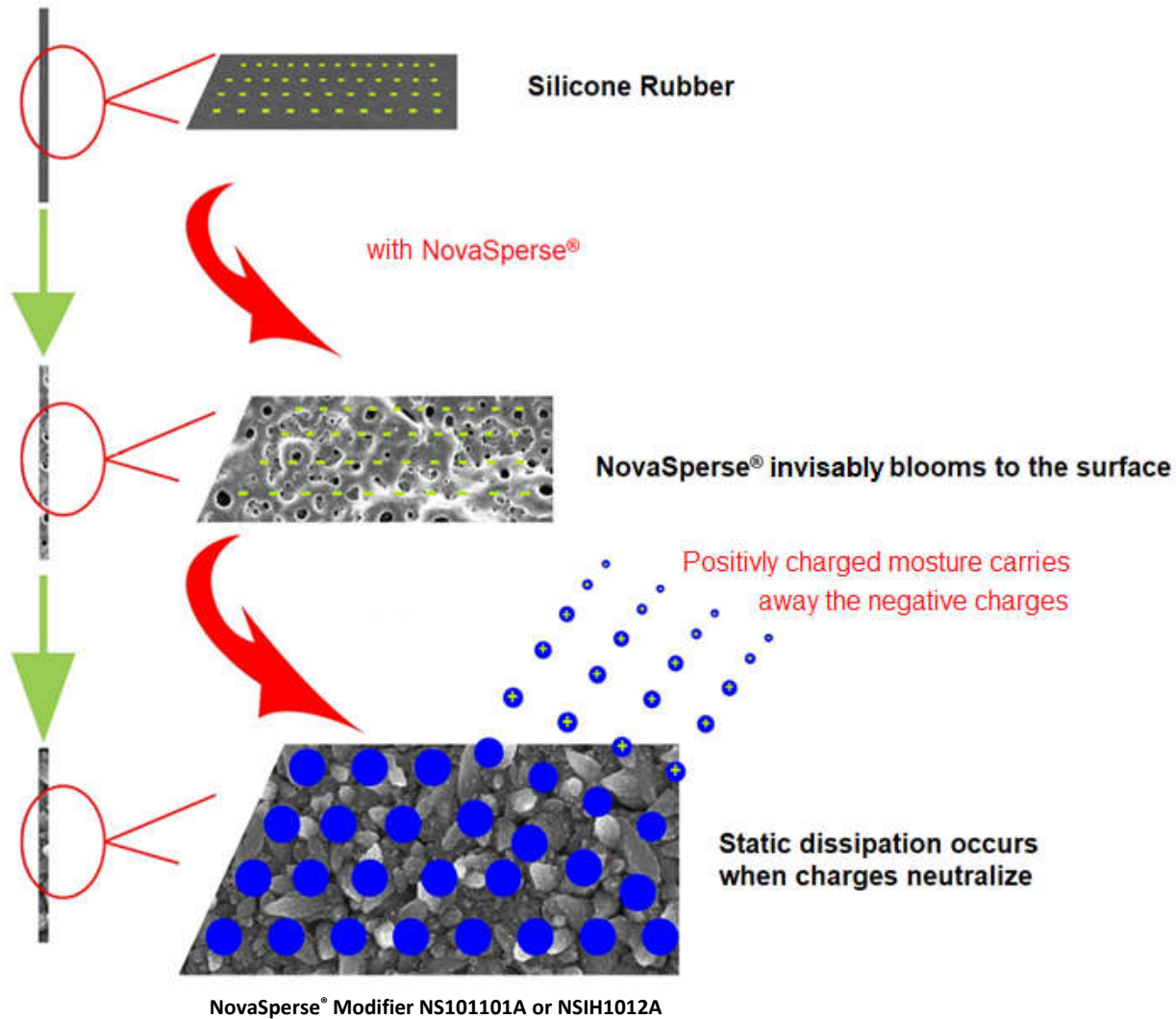
# Silicone Surface Modification - Antistatic

- NovaSperser<sup>®</sup> Modifier Technology
  - Moisture in the air exchanges ions to become net positive (that's why rain provides negatively charged air ions)

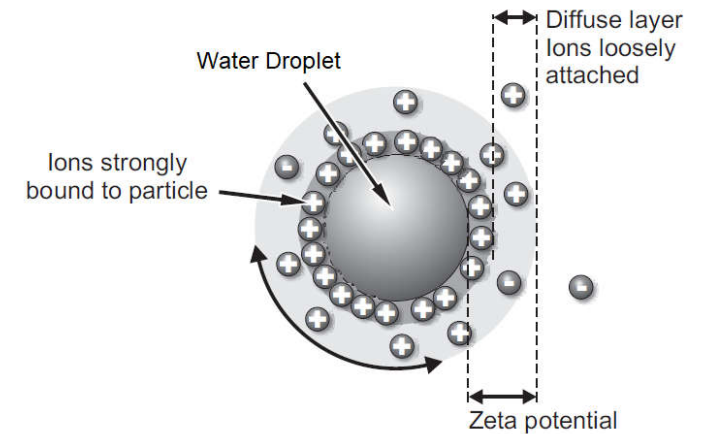
## Moisture Ionic Charge Configuration



# Silicone Surface Modification - Antistatic



## Moisture Ionic Charge Configuration





## Straight Talk...

### Advantages:

- Defeats triboelectric effect
- Wear or damage does not erode performance
- Food Contact per 21 CFR 175.300, 177.2800, and 177.2600
- Human Contact: GRAS by the Cosmetic Ingredient Review Board

### Limitations:

- Service Temperature to 150°C.

## NovaSperse® Modifier Performance

### • Static Dissipative Technology

- $\frac{1}{5}$  a second decay time 5,000v to -500v. Spec is less than 2s
- $\frac{1}{2}$  a second decay from 5,000v to 0v. Spec is less than 10s

### Mil-STD-3010C Method 4046

### Electrostatic Decay at 5% Relative Humidity

Decay Time (5 specimen avg.)	HCR Platinum Cured	With NovaSperse®
+5000V to 500V	>10 seconds (FAIL)	.23 seconds (PASS)
-5000V to -500V	>10 seconds (FAIL)	.23 seconds (PASS)
+5000V to 0V	>10 seconds (FAIL)	.46 seconds (PASS)
-5000V to 0V	>10 seconds (FAIL)	.53 seconds (PASS)

NovaSperse® Modifier NS101101A and NSIH1012A



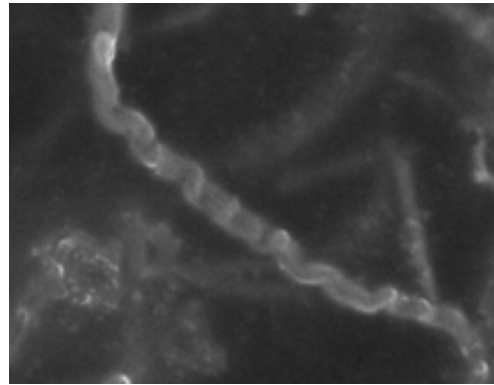
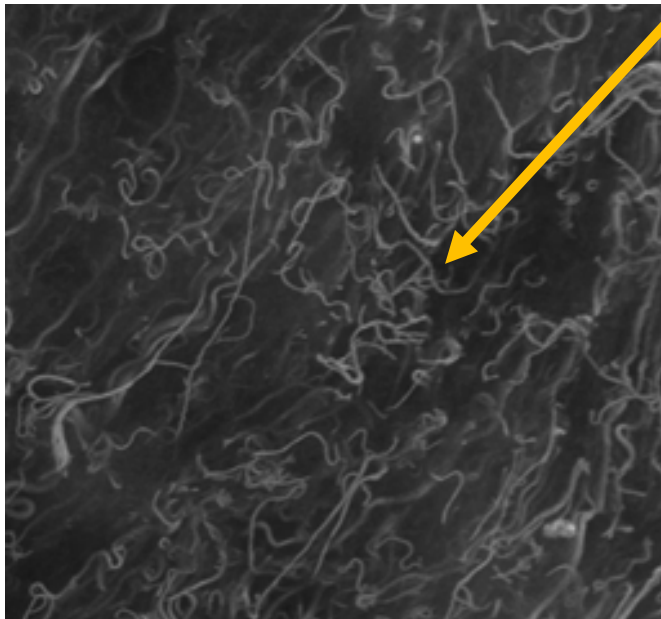
# NEW!

# Nanotechnology for Wearable Medical Devices

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# Electro-Modification of Silicone Rubber



## Patent Pending Technology

- Carbon Nanotubes
- Dispersed in high concentrations into silicone polymer
- Shown here as dispersed into a medical grade silicone rubber:

Shown at the nanometer scale

Width of a Carbon tube approx. 5nm

## Non-invasive Treatments with Neuromodulation

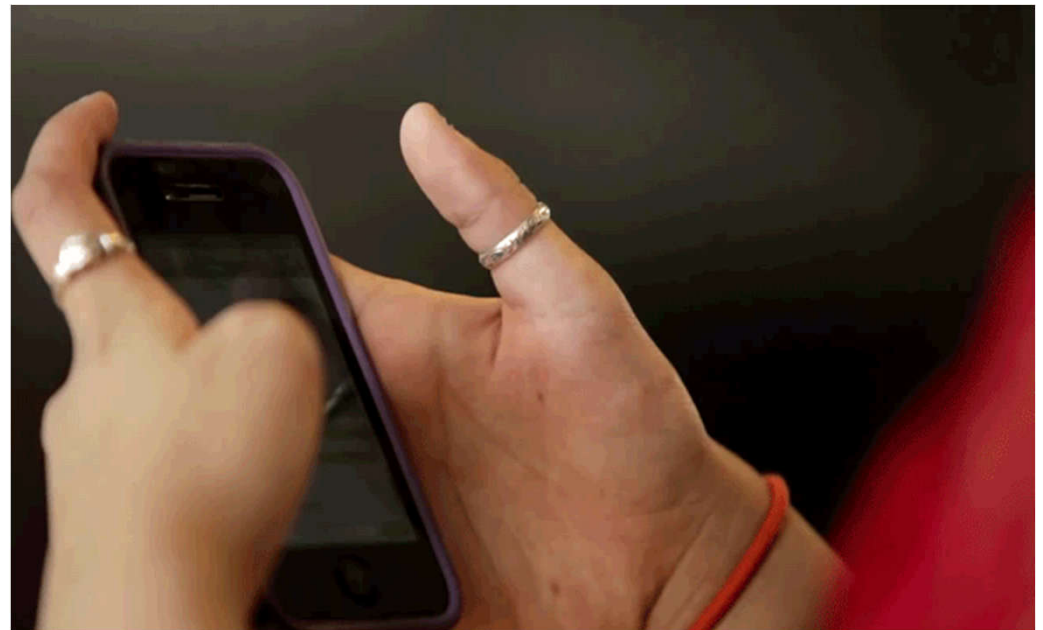
### Case Study:

#### Essential Tremor (ET) Disorder

In essential tremor, an area of the brain called the thalamus sends faulty electrical signals causing the hands, arms, head or voice to shake uncontrollably. ET is a progressive neurological disorder, and the most common movement disorder that affects some 7 million Americans

Affects 4% of the population above the age of 40 and for those 65 and older, there is a 20% prevalence of the disorder.

Louis E, D: The Roles of Age and Aging in Essential Tremor: An Epidemiological Perspective. *Neuroepidemiology* 2019;52:111-118. doi: 10.1159/000492831



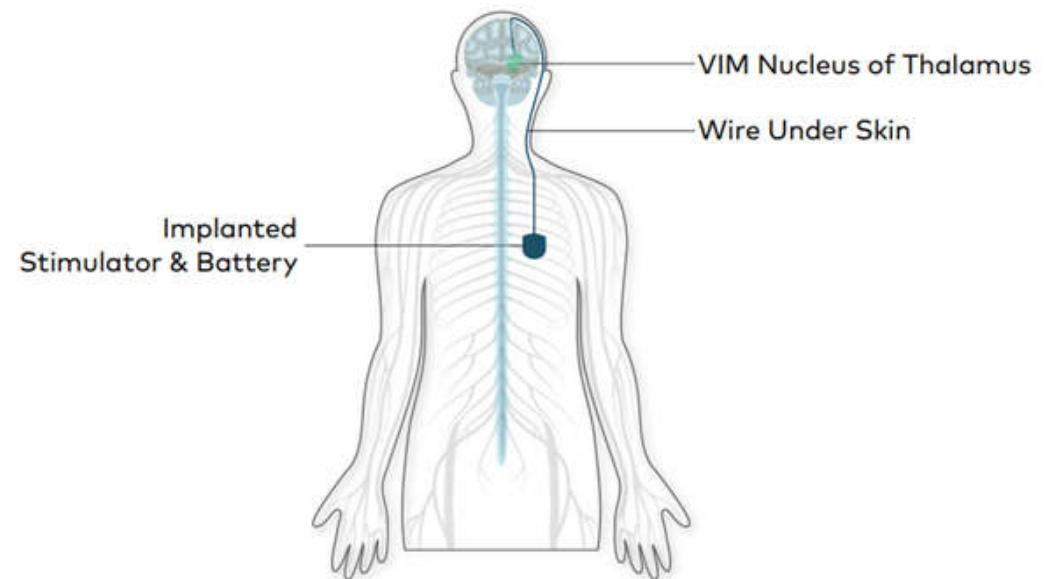
## Non-invasive Treatments with Neuromodulation

### Case Study: ET Disorder

Traditional invasive methods were used:

- Deep Brain Stimulation (pictured)
- Gamma Knife Thalamotomy
- Primidone Drug Therapy<sup>(\*)</sup>

...but now non-invasive  
wearable technology:  
**Neuromodulation**



(\*) Zesiewicz TA, Elble R, Louis ED, et al. Practice parameter: therapies for essential tremor: report of the Quality Standards Subcommittee of the American Academy of Neurology. Neurology. 2005 Jun;64(12):2008-2020. DOI: 10.1212/01.wnl.0000163769.28552.cd.



# Electro-Modification of Silicone Rubber

## Application Example: Dry Skin-Electrode Technology

- Neuromodulation by transcutaneous electrical nerve stimulation (TENS).
  - Low force to skin (less than 1psi).
  - Several months of continuous use.
  - Steady electrical performance:
    - When flexed to conform to body contours.
    - When the patient is on the go.
    - When used during athletic activity (sweaty conditions).
- A 1 in<sup>2</sup> x .078" dry skin-electrode delivers a peak excitation current 15mA to patient with only an applied 3-volt - 100Hz waveform source.

think... a couple of AA batteries delivering an ET therapy for hours.

$$I_{peak} = V_{peak-peak} \frac{\pi \cdot A}{8 \cdot \rho \cdot \ell}$$



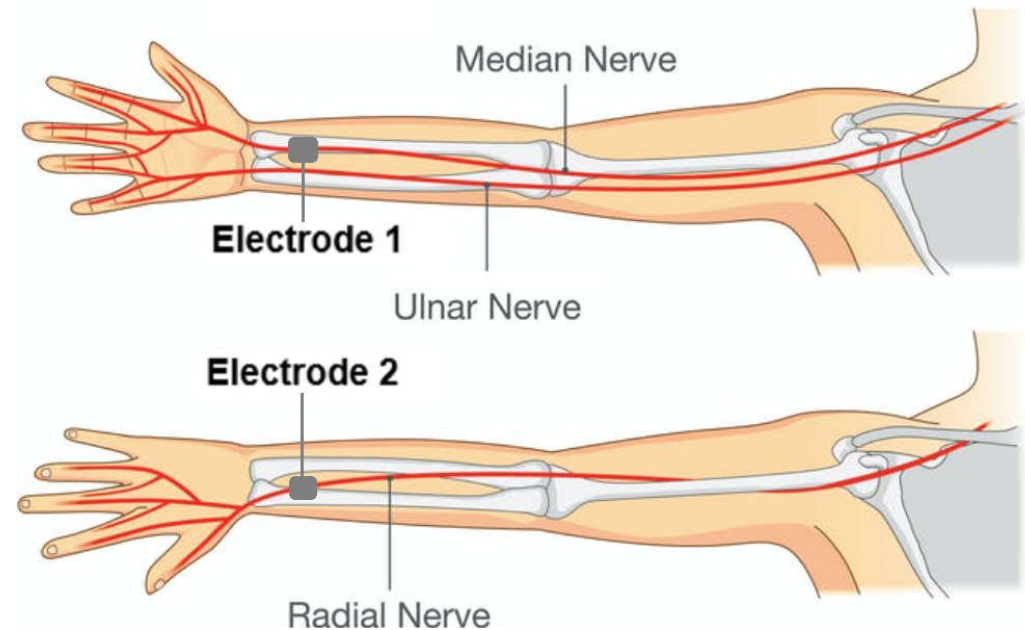
## Non-invasive Treatments with Neuromodulation

### Case Study: ET Disorder

Noninvasive wearable technology:

-Relays to the ventral intermediate nucleus via median and radial nerve stimulation\*

Targeted nerve stimulation using silicone rubber dry-skin electrodes with nanotechnology!



(\*) Dosen S, Muceli S, Dideriksen JL, Romero JP, Rocon E, Pons J, Farina D. Online tremor suppression using electromyography and low-level electrical stimulation. IEEE Trans Neural Syst Rehabil Eng. 2015 May;23(3):385-95. doi: 10.1109/TNSRE.2014.2328296. Epub 2014 Jul 15. PMID: 25051555.

## Non-invasive Treatments with Neuromodulation

### Case Study: ET Disorder

#### Noninvasive wearable technology:

Targeted nerve stimulation using silicone rubber dry-skin electrodes with nanotechnology!

#### Silicone Rubber Dry-Skin Electrodes<sup>\*</sup>:

- Easy on/off comfort
- Lasts 90 days of daily use
- Functions while on the go...

Medical Grade  
Silicone Rubber Dry-  
Skin Electrodes with  
Nanotechnology!



(\*) Isaacson SH, et al. Prospective Home-use Study on Non-invasive Neuromodulation Therapy for Essential Tremor. Tremor and Other Hyperkinetic Movements. 2020; 10(1): 29, pp. 1–16. DOI: <https://doi.org/10.5334/tohm.59>. Illustration excerpted from article.

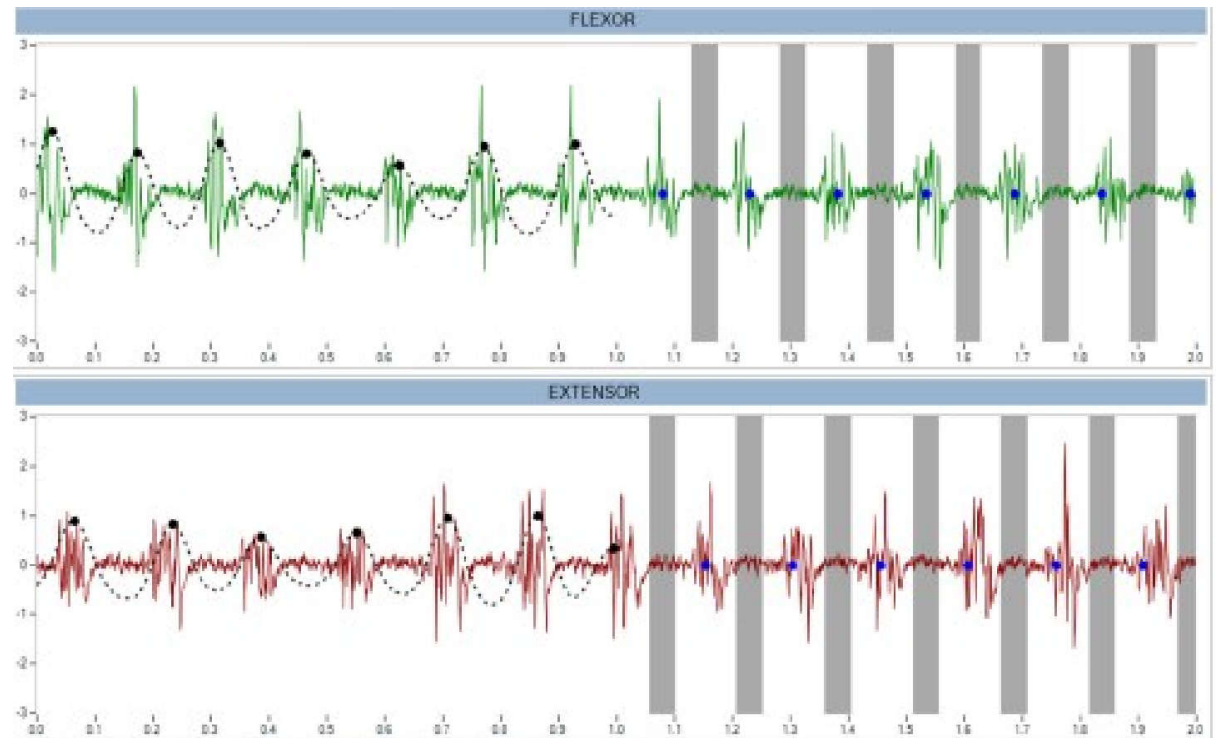
## Non-invasive Treatments with Neuromodulation

### Case Study: ET Disorder

Noninvasive wearable technology:  
Targeted nerve stimulation using our silicone dry-skin electrodes

20ms stimulation pulses of 4-15mA to the antagonist muscles 180° out of phase\*.

(\*) Dosen S, Muceli S, Dideriksen JL, Romero JP, Rocon E, Pons J, Farina D. Online tremor suppression using electromyography and low-level electrical stimulation. IEEE Trans Neural Syst Rehabil Eng. 2015 May;23(3):385-95. doi: 10.1109/TNSRE.2014.2328296. Epub 2014 Jul 15. PMID: 25051555. Illustration excerpted from article.



## Non-invasive Treatments with Neuromodulation

### Case Study: ET Disorder

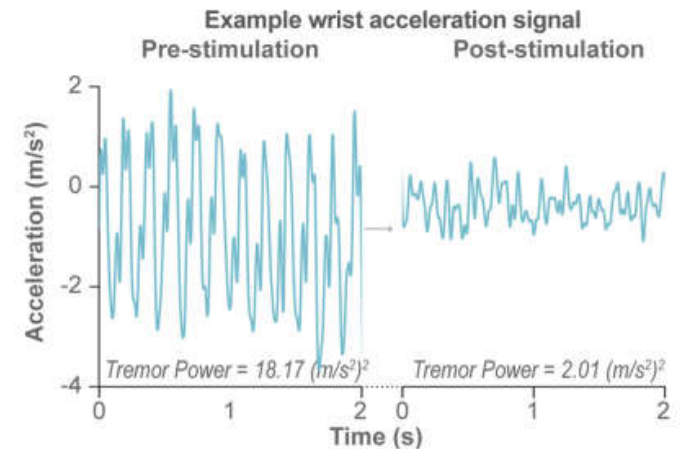
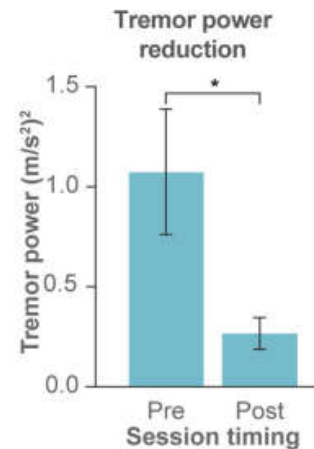
Noninvasive wearable technology:

-August 2020: 193 Patient clinical trial resulted in Tremor Power Reduction\*

#### Efficacy of Clinical Trials

- Typically patients see an 85% Tremor Power Reduction
- Relief endurance was more than 90 minutes

(\*) Isaacson SH, et al. Prospective Home-use Study on Non-invasive Neuromodulation Therapy for Essential Tremor. Tremor and Other Hyperkinetic Movements. 2020; 10(1): 29, pp. 1–16. DOI: <https://doi.org/10.5334/tohm.59>. Illustration excerpted from article.



## Non-invasive Treatments with Neuromodulation

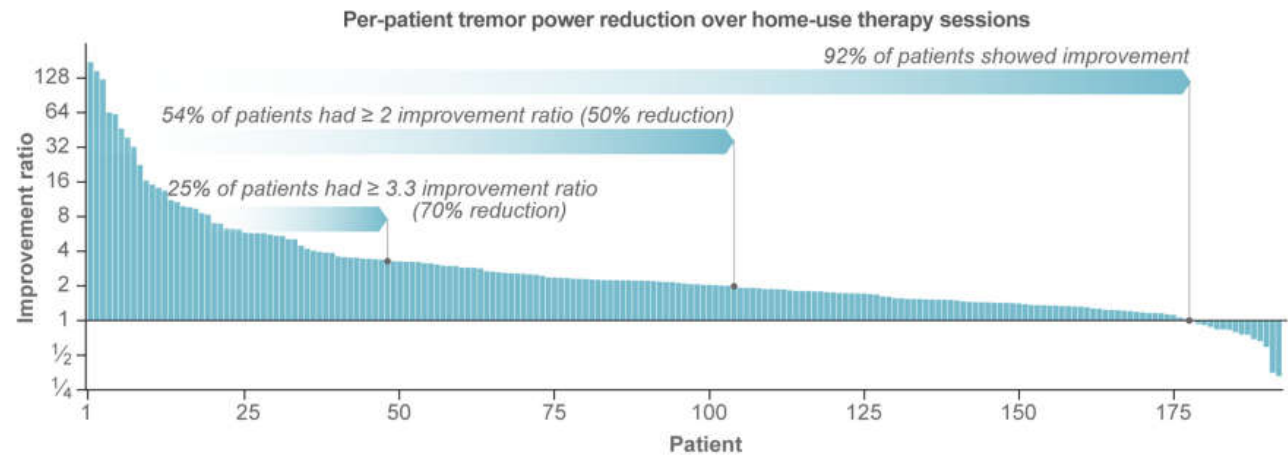
### Case Study: ET Disorder

#### Noninvasive wearable technology:

-August 2020: 193 Patient clinical trial resulted in and Improvement Ratio\*

#### Efficacy of Clinical Trials

- 92% showed Improvement
- 50% showed 2-fold Improvement



(\*) Isaacson SH, et al. Prospective Home-use Study on Non-invasive Neuromodulation Therapy for Essential Tremor. Tremor and Other Hyperkinetic Movements. 2020; 10(1): 29, pp. 1–16. DOI: <https://doi.org/10.5334/tohm.59>. Illustration excerpted from article.



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# Questions?

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- Web: [RDAbbott.com/contact](http://RDAbbott.com/contact)



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