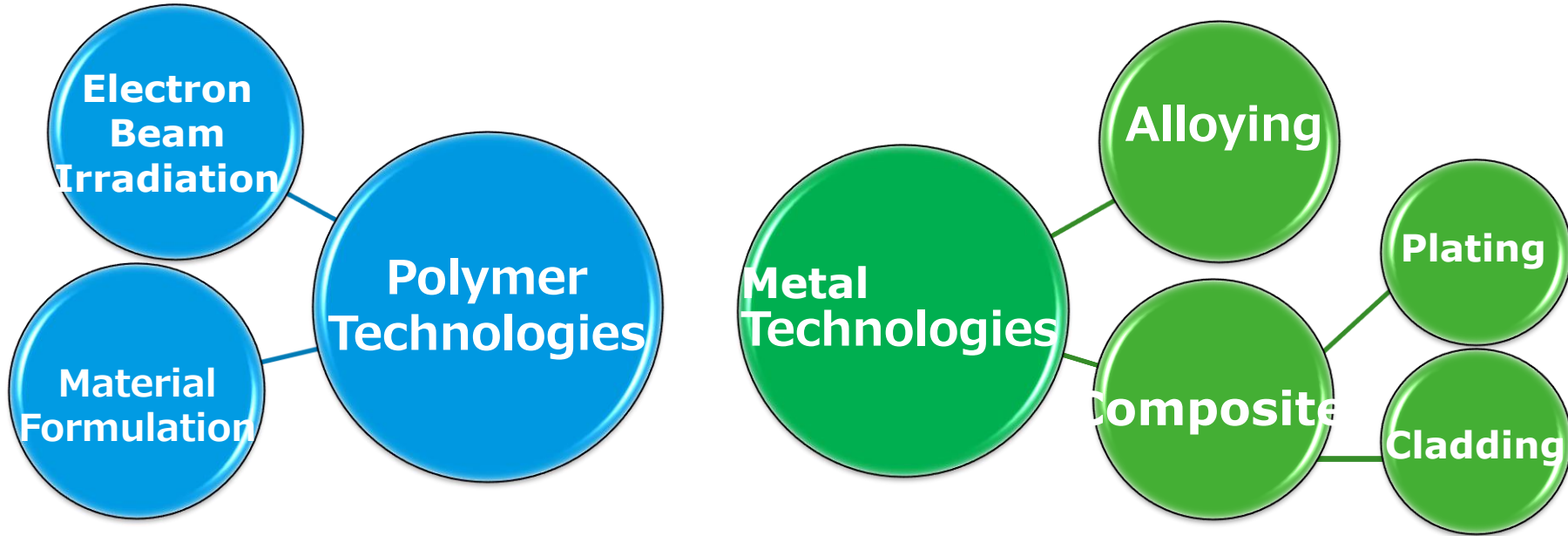


Core Technologies of SEI Products for the Electronics Market

Sumitomo Electric Industries, Ltd.
Interconnect Innovation Project Team
April, 2021

Overview of the Core Technologies



SEI has been developing and modifying our products for the electronics market, by utilizing our core technologies such as polymer technologies including electron beam irradiation and material formulation, as well as metal technologies including alloying and composite such as plating and cladding. The details are explained in the following slides.

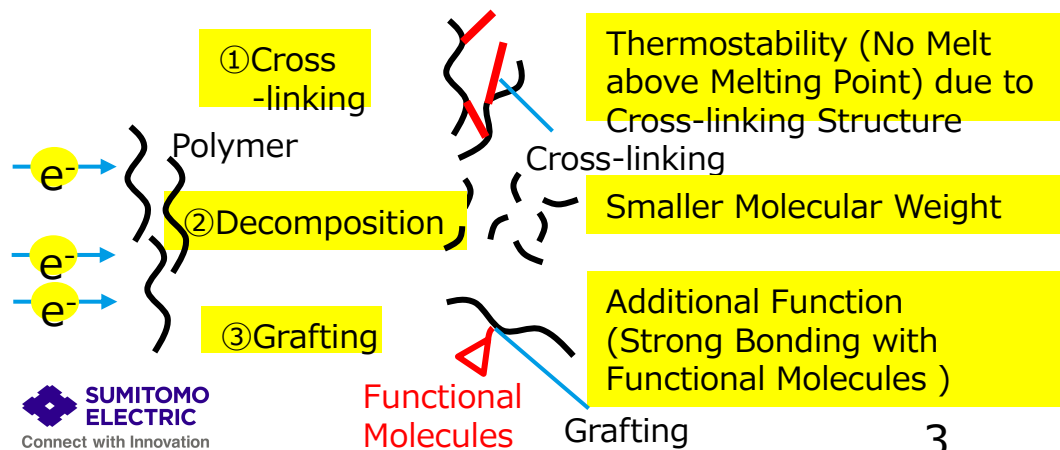
If you have any technical issues that could be solved by our technologies, please feel free to contact us.

Contact: iipt@info.sei.co.jp

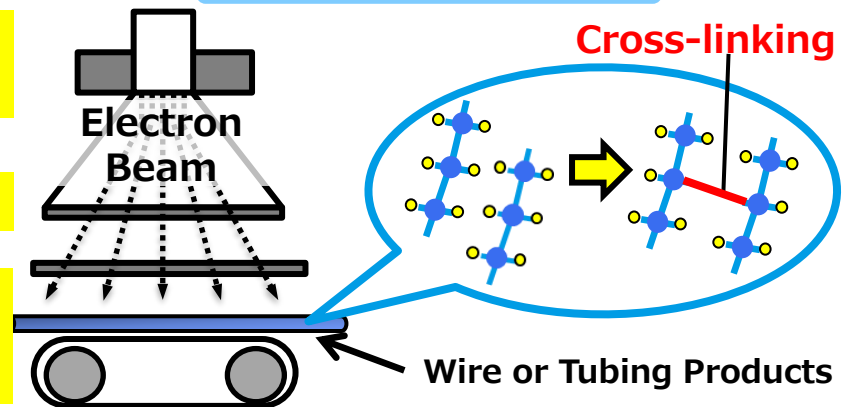
What is Electron Beam Irradiation?

- Applying electron beam irradiation on polymers such as polyethylene causes three reactions including cross-linking, decomposition, and grafting. SEI has developed various products by using cross-linking or grafting.
- Cross-linking is chemical reaction that creates intermolecular bonds. This attains characteristics such as heat-resistance, oil and chemical resistances, mechanical strength, and shape memory effect.
- Decomposition of polymer chains also occurs at the same time. In case cross-linking exceeds decomposition, cross-linking effect can be utilized.
- Grafting is chemical reaction that adds new characteristics to polymer by bonding molecules which have different functions such as flame-retardancy, to the trunk of the polymer.
- The principle of electron beam irradiation is the same as that of CRT television and it is safe as the irradiation is completely suspended by power-off. Irradiated products are chemically stable and have been used for many years.

Three Reactions through Irradiation



Irradiation Process



Benefits of Electron Beam Irradiation

The following characteristics are able to be enhanced or added to "Finished Products".

Enhance characteristics of polymers

Heat-resistance

Mechanical Strength

Oil & Chemical Resistances

Add new characteristics to polymers

Flame-retardancy

Shape Memory Effect

Varieties of polymers are able to be cross-linked

Polyolefin

Rubber

Polyamide

Polyester

Polyurethane

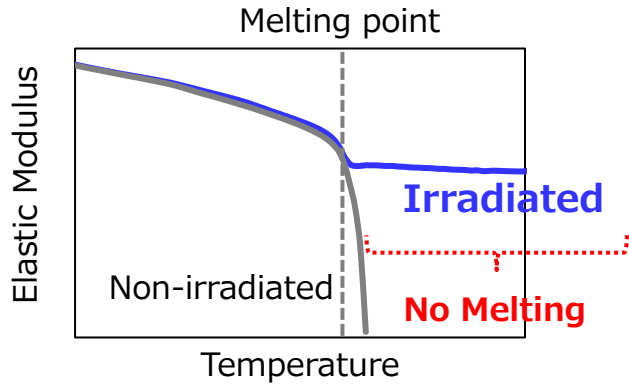
Fluoropolymer

Silicone

PVC

Applications of Electron Beam Irradiation

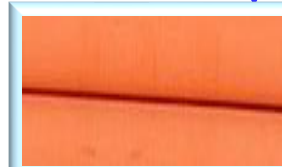
Heat-resistance



Heat-resistant Wire



Heat-pillar (250°C, 3s)

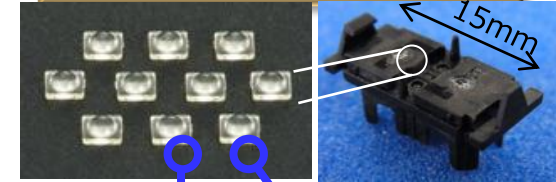


Irradiated



Non-irradiated

Reflow Soldering Resistant Optical Lens



Reflow soldering (260°C)



Irradiated

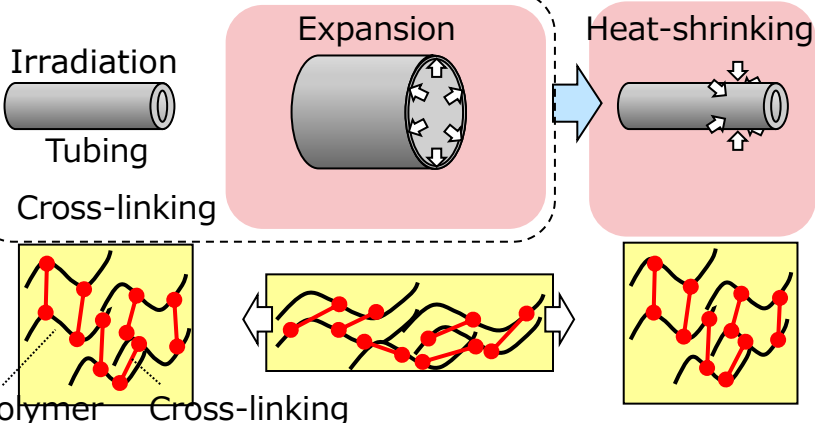


Non-irradiated

Shape Memory Effect

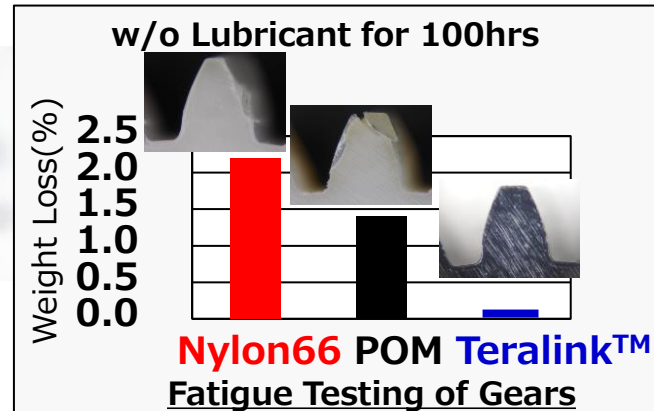
Heat-shrinkable tubing

Manufacturing Process



Mechanical Strength

Wear & Fatigue (Abrasion) Resistant Parts



Material Formulation Technology

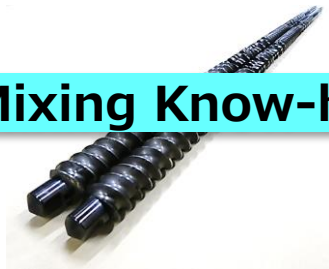
Formulation Technology

Theoretical Study, Not Enough



Synergetic Effects through Huge Data, Based on Experimental Results

Mixing Know-how



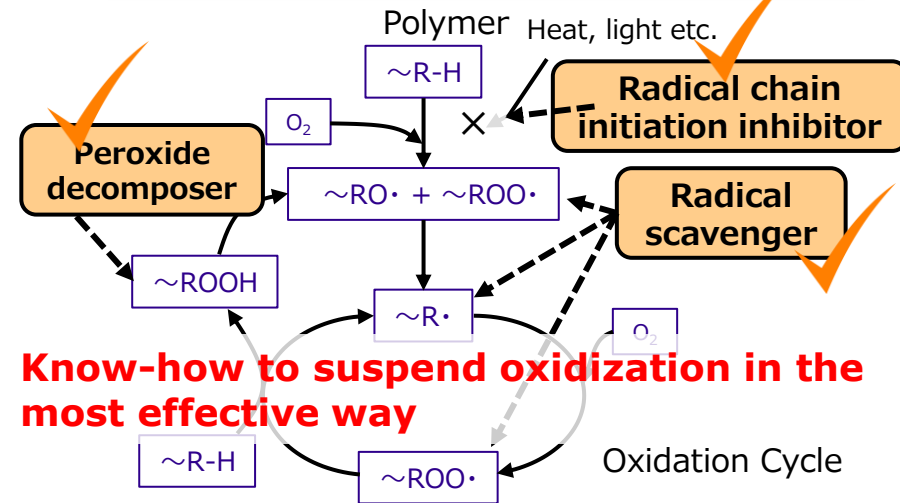
- Polymers
- Effective Additive and Fillers

Flame-retardancy, Heat-resistance, Abrasion resistance, Adhesion, etc.

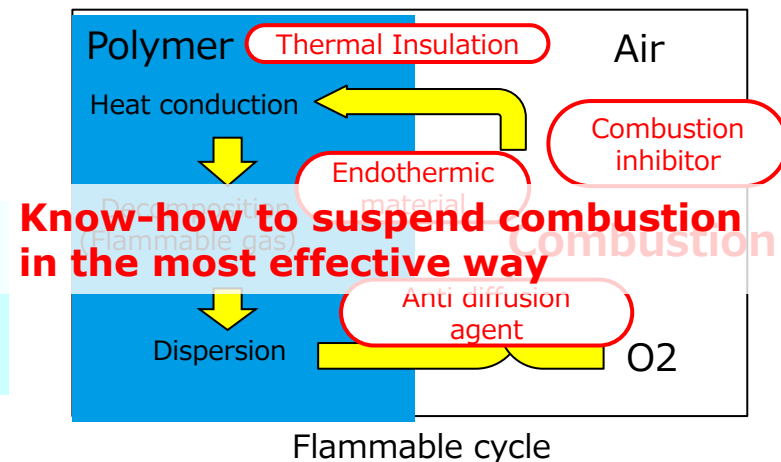
Mechanical Strength, Adhesion, Flow Rate

- Polymer Alloy
- Polymer Nano-composite

Heat aging resistant (Anti-oxidation) Technology



Flame-retardant Technology

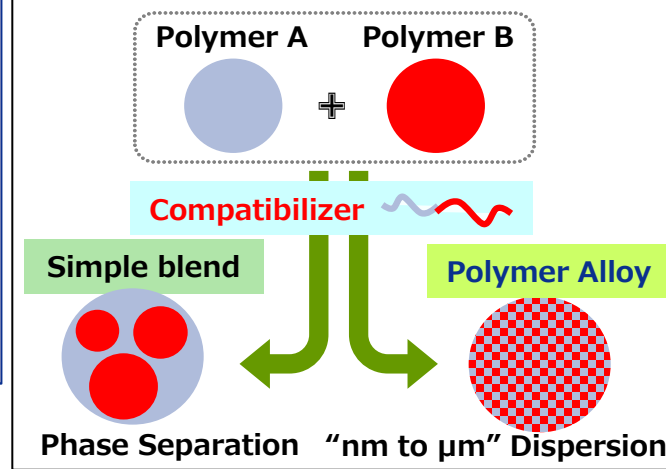


Flammable cycle

Polymer Alloy Technology

- ★ Fine dispersion technology to mix mutually immiscible polymers
- ★ Create new material with merits of both polymers

What is "Polymer Alloy"?



Benefits Adhesion

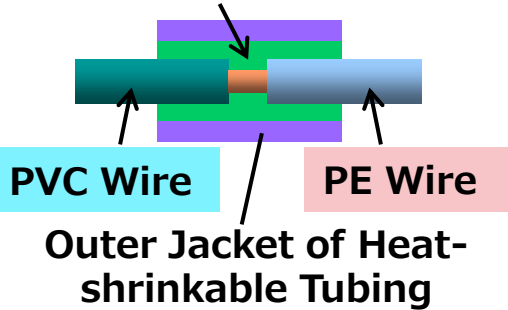
Greater peeling strength
Better adhesion to multiple materials

Mechanical Strength

Rigidity and impact resistance
Flexibility and abrasion resistance

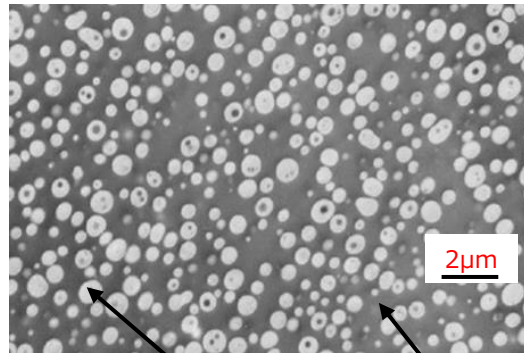
Water proof, heat-shrinkable tubing for harnessing wires

Hot-melt Adhesive



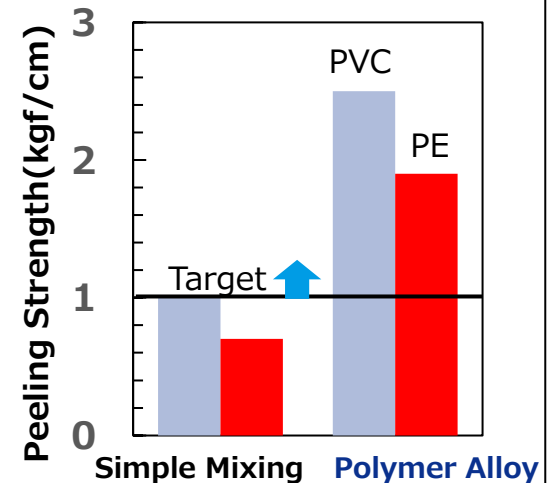
Better Adhesion both for PVC & PE Wires

TEM Image for "nm Dispersion"



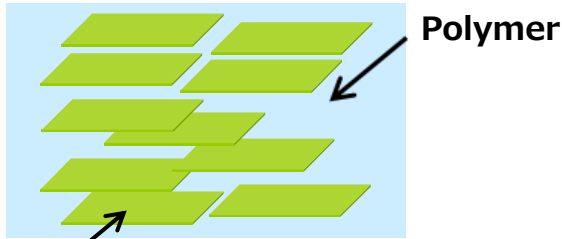
For "PVC Wire"

For "PE Wire"



Polymer Nano-composite Technology

What is "Nano-composite"?



Filler in a Nanometer Size

Fillers Dispersed in a Polymer

Benefits

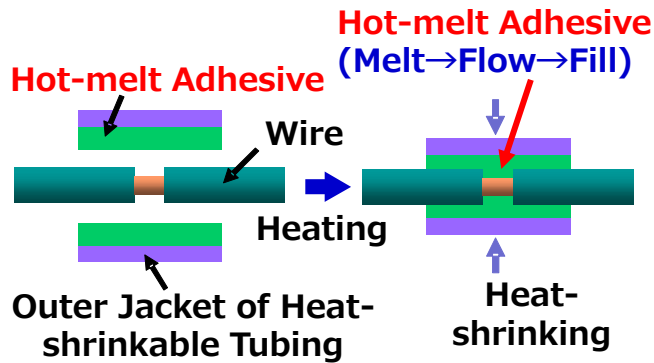
Mechanical Strength

Greater tensile strength
Better flexural rigidity

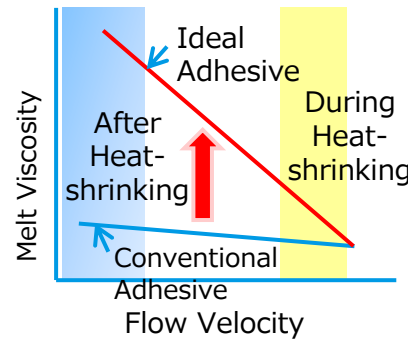
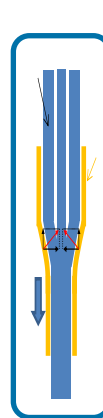
Adhesive Property

Low flow rate @ elevated temperature, after installation
High flow rate during heat-shrinking

Water proof, heat-shrinkable tubing for harnessing wires

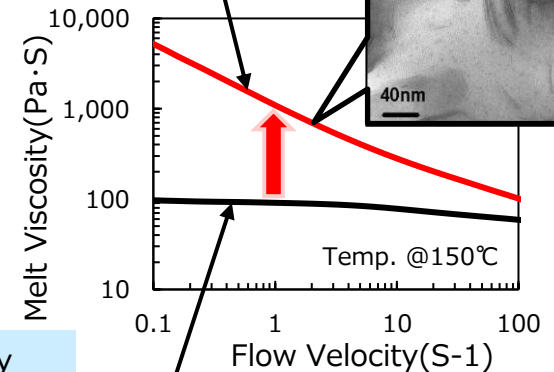


Vertical testing in thermostatic chamber (150°C, 24Hours)



After Shrinking: High Viscosity
During Shrinking: Low Viscosity

Nano-composite Adhesive



Conventional Adhesive

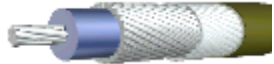
Metal Technologies and Applications

Conductor

Al alloy wire for power lines

Cu alloy wire for medical equipment

Composite metal wire for spark plug



Al wire for coil

Ni alloy/Cu

- High oxidation resistance
- High thermal conductivity



Alloy design & super fine wire drawing

Al alloy wire for automobile



Composite

Oxygen free Cu wire



Cu wire for coil

Up casting

Al alloy for bicycle



Drawing

Cu wire for power lines

Alloy design

Al wire for power lines



Ni·Co·Fe alloy wire

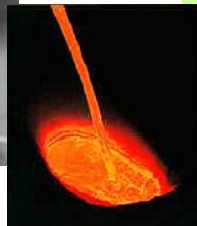


Fine wire continuous casting

Ni alloy wire for spark plug

Continuous casting & rolling

Component



Metal Technologies

Improvement of characteristics by alloying, and addition of functions by composite

Alloying



Improvement of characteristics

Electrical conductivity
Mechanical property

Change in electrical
resistance

Heat-resistance

Corrosion
resistance

Composite



Addition of functions

Electrical
conductivity

Weight
reduction

Solderability

Corrosion
resistance

Enlarging
surface area

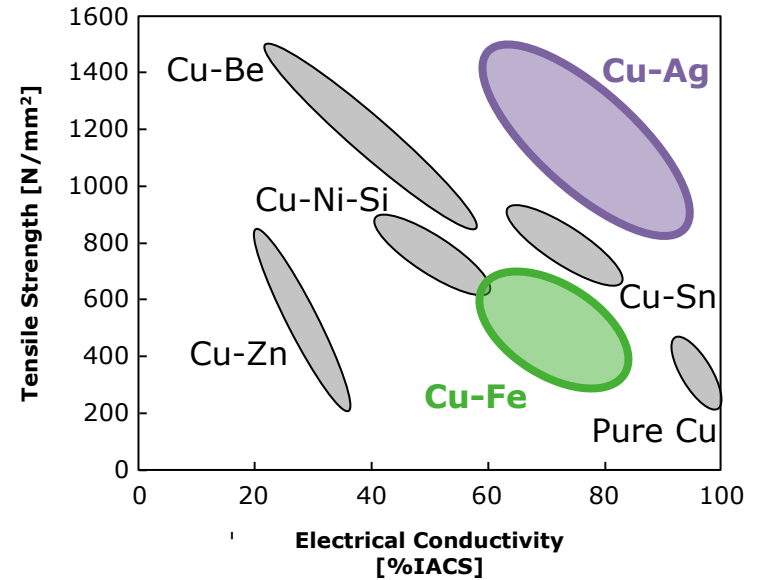
Alloying Technology

Ni Alloy Wire (SSNi™)

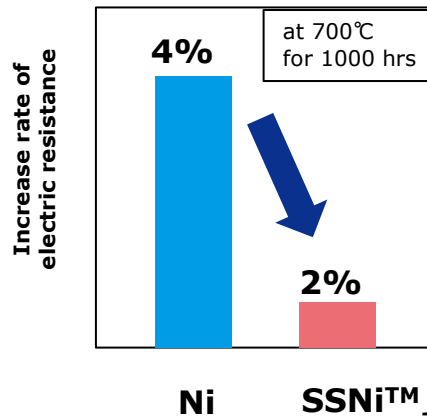
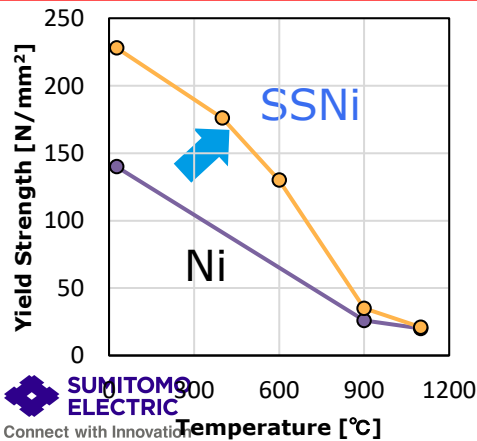
SSNi™ possesses higher oxidation resistance and stabler electrical property at high temperature than pure nickel due to the intermetallic compound precipitations.



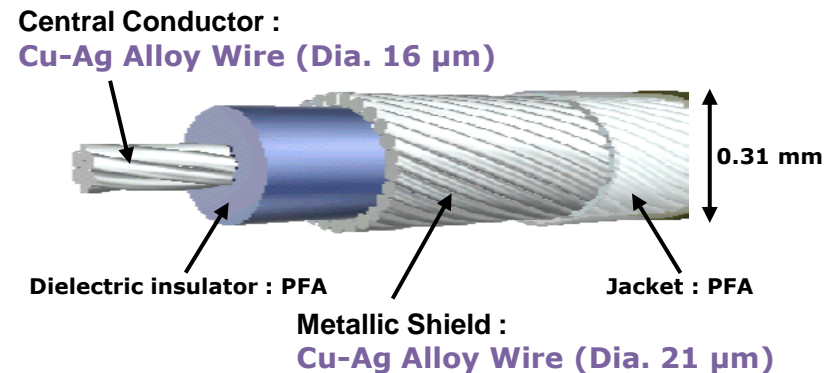
High Strength Cu Alloy



Comparison of yield strength and electric resistance change at high temperature between SSNi™ and Ni



Application for medical equipment cable



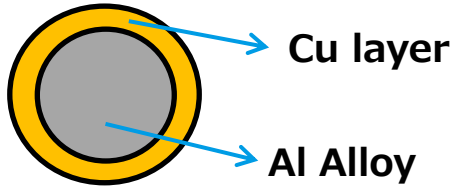
Composite Technologies

Composite by cladding

Cladding is a technology to fit metal layer on another metal mechanically. SEI produces composite wire by unique cladding technology.

Cu clad Al (CCA) : Core material is light and high strength Al alloy and outer layer is copper. Specific gravity is about half of Cu.

Cu clad Al (CCA)



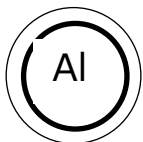
	Light Weight	Electrical Conductivity	Solderability	Corrosion Resistance *
Cu/Al Composite	○	○	◎	×
Al Alloy	◎	△	×	○
Cu Alloy	×	◎	◎	△

* Corrosion resistance can be improved by processing terminal cross section.

Composite by plating

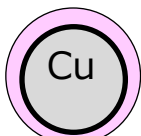
SEI produces composite material by covering metal on another metal by unique plating technology.

Light weight conductor



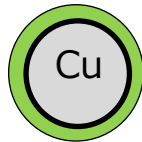
Sn

Heat-resistant conductor



Ni

High frequency conductor



Ag

Ni Plated Cu Composite Wire

	Heat-Resistance	Electrical Conductivity	Solderability	Corrosion Resistance
Ni/Cu Plating	○	○	○	○
Ni Alloy	◎	×	○	○
Cu Alloy	×	○	◎	△

Plating Technology

Improving material characteristics, adding new functions, making microstructure and plating on various materials

Improve material characteristics

Corrosion
resistance

Add new functions

Reduction of
contact resistance

Electrical
Conductivity

Bondability

Electromagnetic
shield

Magnetic
property

Microstructure

Fine Pitch FPC

Ultra small
part

Porous metal

Various materials

Alloyed
material

Electrical
insulation
material

“Application of plating” to porous metal, Celmet™

Enhancement of core technology

■ Alloy technology

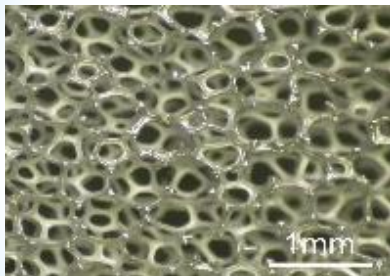
High corrosion resistance
High heat-resistance

NiCr Celmet™
NiSn Celmet™(*U/D)
NiSnCr Celmet™(*U/D)
NiW Celmet™(*U/D)

- Fuel cell current collector
- Catalyst support filter

Core technology

- Plating
- Heat treatment
- Electrochemical evaluation



- Dispersive plating
- Surface modification
- Surface miniaturization

Large surface area
Catalyst support

Large surface area Celmet™(*U/D)
Catalyst support Celmet™(*U/D)

- Alkaline water electrolysis electrode
- Salt electrolysis electrode

Current application

Ni Celmet™



● Ni metal hydride battery current collector (From Y2002)

- Filter
- Catalyst Support
- Mist generator
- Electromagnetic Shield
- Cushioning material

Organic electrolyte resistance

■ Non-water plating

Al Celmet™(*U/D)

■ Molten salt plating

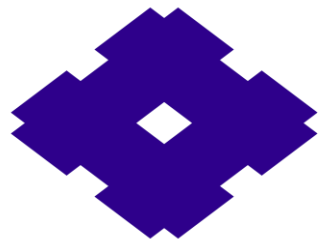
- LIB current collector
- Capacitor current collector

Biocompatibility
Corrosion resistance
Mechanical strength

NiTi Celmet™(*U/D)

- Medical material
- Electrode material

Develop high functional Celmet that meets customers' needs



**SUMITOMO
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