



Ultra Fast Radio Frequency Lamination for Large Armor Panels

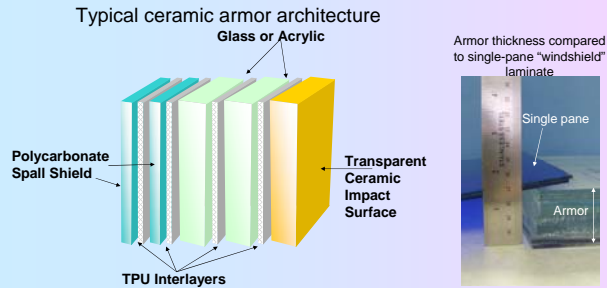


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Transparent Ceramic Armor

- Several layers of glass, transparent ceramics, & structural plastics
- Preferred bonding interlayer is thermoplastic polyurethane (TPU)
- Total thickness 1" to 6"
- 3 to 7 interlayers per armor panel
- Long, energy intensive autoclave processes used currently



About FastFuse™ RF Lamination

Uses existing industrial RF pressing equipment

FastFuse™ → 1 to 5 minute process

Autoclaving → 1 to 6 hours

95% energy savings

RF energy penetrates low dielectric materials

Glass, ceramics, polycarbonate, acrylic

RF absorbed by higher dielectric interlayers

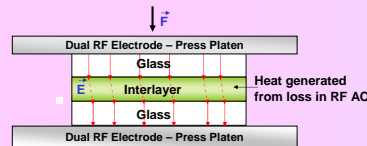
Vinyl (PVB, EVA, PVC) & polyurethane (TPU)

RF transmitted across conductive materials

Solar cells, metallized glass, and LEDs can be embedded



4 ton RF Press 18" x 20"



Experimental

FastFuse™ process steps

Lay-up the laminates → Vacuum bag → Apply pressure & RF energy in RF Press → Adjust RF energy, pressure, and time for different interlayers → Cool and release vacuum

TPU interlayers used for armor specimens

- TPU has high strength and bonds to PC & glass
- Requires lower temperature than PVB
- Protects polycarbonate from softening and warping



Above: edge view, below: top view Of armor panel prior to lamination The TPU becomes transparent when laminated



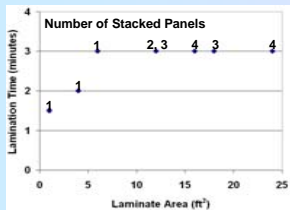
19 ton RF Press 30" x 40"



Vacuum bag with panel loaded into RF Press for FastFuse lamination

FastFuse™ Results

Lamination time independent of thickness



Sizes of RF laminated glass

Laminated sizes

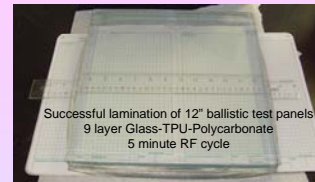
36" x 24"	6 ft ²
24" x 24"	4 ft ²
18" x 16"	2 ft ²
12" x 12"	1 ft ²
9" x 9"	0.56 ft ²
6" x 6"	0.25 ft ²
4" x 4"	0.11 ft ²



Armor Results



Thick acrylic/polycarbonate panels with TPU 3 minute RF cycle



Successful lamination of 12" ballistic test panels 9 layer Glass-TPU-Polycarbonate 5 minute RF cycle



Dual cell solar panel Wired in parallel 6" x 6.5" glass with PVB

RF laminated solar panel and LEDs indicate applications for armored vehicle energy generation and embedded sensors



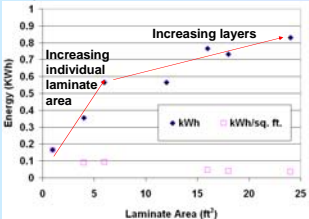
3-color LED after press Blue-Green-White (top to bottom) 9" square glass with PVB

RF lamination bonds wires to solar cells without use of solder → **Pb free**

Conclusions & Future Direction

- FastFuse™ RF Lamination laminates thick and thin, glass, ceramic and plastic materials significantly faster than conventional autoclaving and vacuum methods
- FastFuse™ is an energy efficient, flexible, green alternative for armor manufacturing
- FastFuse™ is commercially ready for use for sizes up to 24" x 36"
- Ceralink is setting up an on-site laboratory for FastFuse™ R&D
- Ceralink is seeking innovative manufacturers to implement FastFuse™ RF Lamination

Lamination energy dependent on area and thickness



4 laminates stacked, 2' x 2' each 16 ft² in 3 minutes

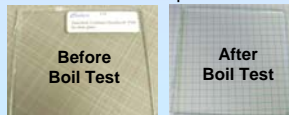


Energy Consumed: 0.76 kWh

FastFuse™ RF energy: 47.5 kWh / 1,000 ft²

Autoclaving energy: 1150 to 4000 kWh / 1,000 ft²

Accelerated environmental testing RF laminated TPU passes boil test



Dureflex® A4700 TPU in glass

2 hrs in boiling water Samples passed test no new bubbles no delamination no haze

Ceralink inc Troy, New York (518) 283-7733 www.ceralink.com

Ceralink has patented FastFuse™ and made it available through the RF equipment manufacturer



Ceralink acknowledges support from:

