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(54) **FLEXIBLE ELECTRICALLY CONDUCTIVE FILM**

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(56) **References Cited**

U.S. PATENT DOCUMENTS

3,302,002	A	1/1967	Warren
3,311,517	A	3/1967	Keslar et al.
3,529,074	A	9/1970	Lewis
3,601,471	A	8/1971	Seddon et al.
3,682,528	A	8/1972	Apfel et al.
3,752,348	A	8/1973	Dickason et al.
3,897,140	A	7/1975	Tuthill
3,990,784	A	11/1976	Gelber
4,017,661	A	4/1977	Gillery
4,166,876	A	9/1979	Chiba et al.
4,226,910	A	10/1980	Dahlen et al.
4,234,654	A	11/1980	Yatabe et al.
4,320,169	A	3/1982	Yatabe et al.
4,413,877	A	11/1983	Suzuki et al.
4,537,814	A	8/1985	Itoh et al.
4,590,118	A	5/1986	Yatabe et al.
4,639,069	A	1/1987	Yatabe et al.
4,645,714	A	2/1987	Roche et al.
4,696,719	A	9/1987	Bischoff
4,722,515	A	2/1988	Ham
4,782,216	A	11/1988	Woodard
4,786,783	A	11/1988	Woodard
4,799,745	A	1/1989	Meyer et al.
4,842,893	A	6/1989	Yializis et al.
4,910,090	A	3/1990	Kuhlman et al.
4,954,371	A	9/1990	Yializis
4,965,408	A	10/1990	Chapman et al. ..... 174/35 MS
4,973,511	A	11/1990	Farmer et al.
5,011,585	A	4/1991	Brochot et al.
5,018,048	A	5/1991	Shaw et al.
5,032,461	A	7/1991	Shaw et al.
5,071,206	A	12/1991	Hood et al.
5,085,141	A	2/1992	Triffaux
5,091,244	A	2/1992	Biornard
5,097,800	A	3/1992	Shaw et al.
5,125,138	A	6/1992	Shaw et al.
5,260,095	A	11/1993	Affinito
5,324,374	A	6/1994	Harmand et al.
5,332,888	A	7/1994	Tausch et al.
5,356,947	A	10/1994	Ali et al.
5,360,659	A	11/1994	Arends et al.
5,395,644	A	3/1995	Affinito
5,440,446	A	8/1995	Shaw et al.
5,489,489	A	2/1996	Swirbel et al.
5,547,508	A	8/1996	Affinito
5,681,615	A	10/1997	Affinito et al.
5,681,666	A	10/1997	Treger et al.
5,686,360	A	11/1997	Harvey, III et al.
5,699,188	A	12/1997	Gilbert et al.
5,725,909	A	3/1998	Shaw et al.
5,744,227	A	4/1998	Bright et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	0 810 452 A2	12/1997
EP	0873839 A1	10/1998
EP	0944299 A2 A3	9/1999
EP	0977167 A1	2/2000
WO	WO 92/12219	7/1992
WO	WO 95/10117	4/1995
WO	WO 97/01440	1/1997
WO	WO 97/01778	1/1997
WO	WO 97/04885	2/1997
WO	WO 98/26927	6/1998
WO	WO 99/36248	7/1999
WO	WO 99/36262	7/1999
WO	WO 00/26973	5/2000
WO	WO 00/48749	8/2000
WO	WO 01/31393 A1	5/2001
WO	WO 01/58989 A1	8/2001
WO	WO 01/96104 A2	12/2001
WO	WO 01/96115 A1	12/2001

OTHER PUBLICATIONS

Article: Cairns et al., "Strain–Dependent Electrical Resistance of Tin–Doped Indium Oxide on Polymer Substrates," *Applied Physics Letters*, vol. 76, No. 11, Mar. 13, 2000, pp. 425–427.

(Continued)

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(57) **ABSTRACT**

An electrically conductive film contains electrically connected first and second visible light-transmissive metal or metal alloy layers separated by a visible light-transmissive crosslinked polymeric layer. The film can be joined or laminated into glazing (especially non-planar vehicular safety glazing) with reduced likelihood that the metal or metal alloy layers will be damaged or distorted. The film also can transparently shield a device that can cause or is sensitive to electromagnetic interference with reduced likelihood that the metal or metal alloy layers will fracture.

21 Claims, 9 Drawing Sheets