Characterization of a glass frit free TiCuAg-thick film metallization applied on aluminium nitride

R. Reicher**, W. Smetana**, A. Adlaßnig*, J. C. Schuster* and U. Gruber*

*Institute of Physical Chemistry, University of Vienna
**Institut für Werkstoffe der Elektrotechnik, Technical University of Vienna

The metallization of aluminium nitride substrates by glass frit free Ti CuAg-thick film pastes were investigated. Adhesion properties of the conductor paste were tested by measuring tensile strength and compared with commercial Cu-thick film pastes (within glass frit). Also numerical analysis of temperature-distribution and thermal extension of metallized aluminium nitride ceramic, induced by a continuous and a pulsed working electronic device were made with a finite element program.

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Roland Reicher, Walter Smetana
Institut für Werkstoffe der Elektrotechnik, Technische Universität Wien, Vienna, Austria

Alexander Adlaßnig, Julius C. Schuster, U. Gruber
Institut für Physikalische Chemie, Universität Wien, Vienna, Austria

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Adhesion Properties

commercial / own
Cu-thick film pastes

tensile strength

Numerical Analysis

continuous / pulsed
working electronic device

temperature-distribution
thermal expansion

Identify number	Manufacturer	Firing temperature	Annotation
58 43	EMCA-Remex	600°C	
91 53	DuPont	900°C	
60 01	DuPont	600°C	
N°. 4		850°C/950°C	1 at% Ti
N°. 5		850°C/950°C	2.5 at% Ti

Table 1: Identify number, manufacturer and firing temperature of various Cu-thick film pastes, used for measure adhesion strength

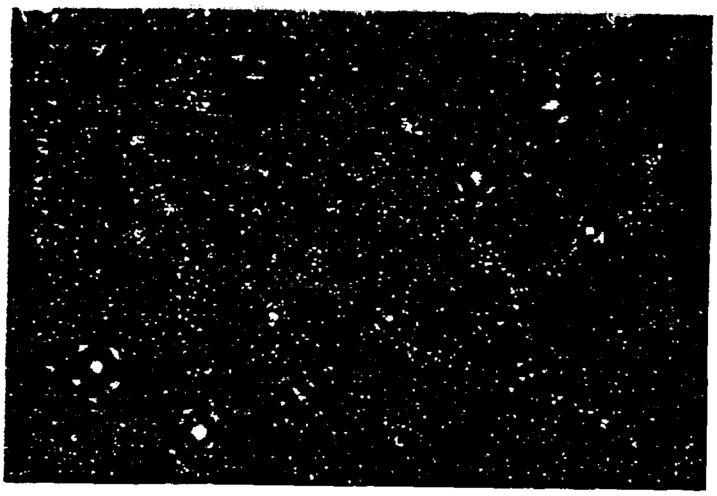

Figure 1: Microscopy view of TiCuAg-thick film paste N°.4, fired at 950°C/10min shows ball-shaped structures (magnification: 50)

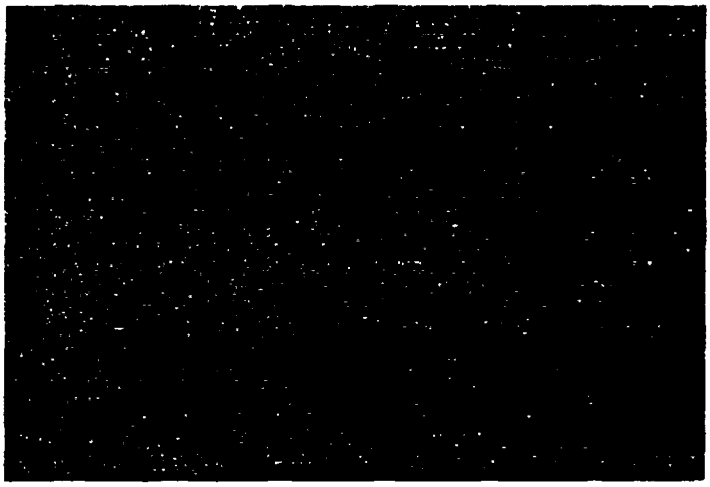

Figure 2: Microscopy view of TiCuAg-thick film paste N°.4, fired at 850°C/10min shows also cracks (magnification: 50)

Figure 3: Cross-sectional view of metallized AlN ceramic after three printings (magnification: 50)

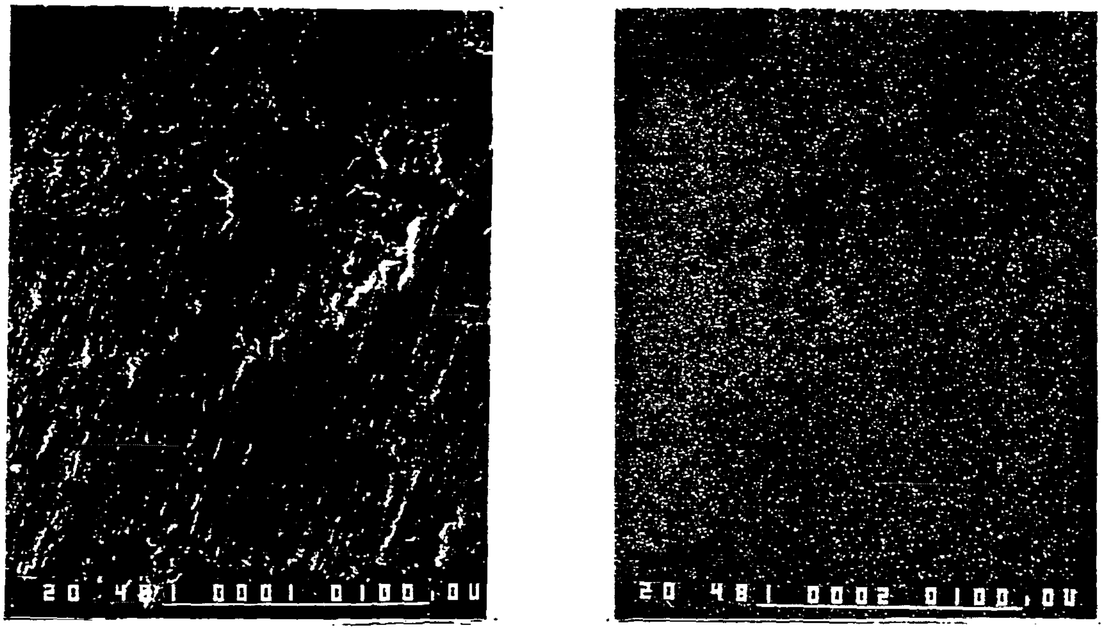

Figure 4: Cross-sectional scanning electron micrograph images of metallization and Ti-distribution (Paste N°.5, 2.5 at% Ti, magnification: 480)

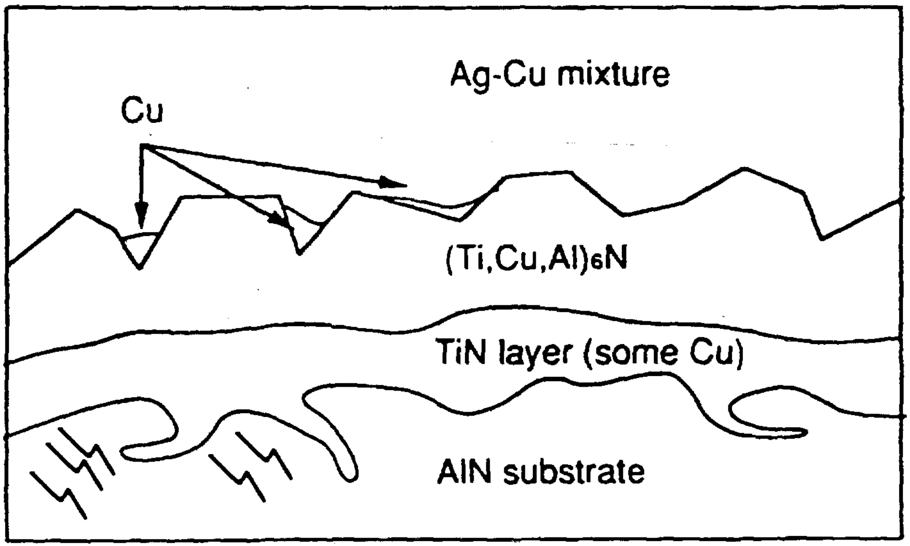

Figure 5: Schematic diagram of the phases and morphologies at the reacted AlN-Cu interface

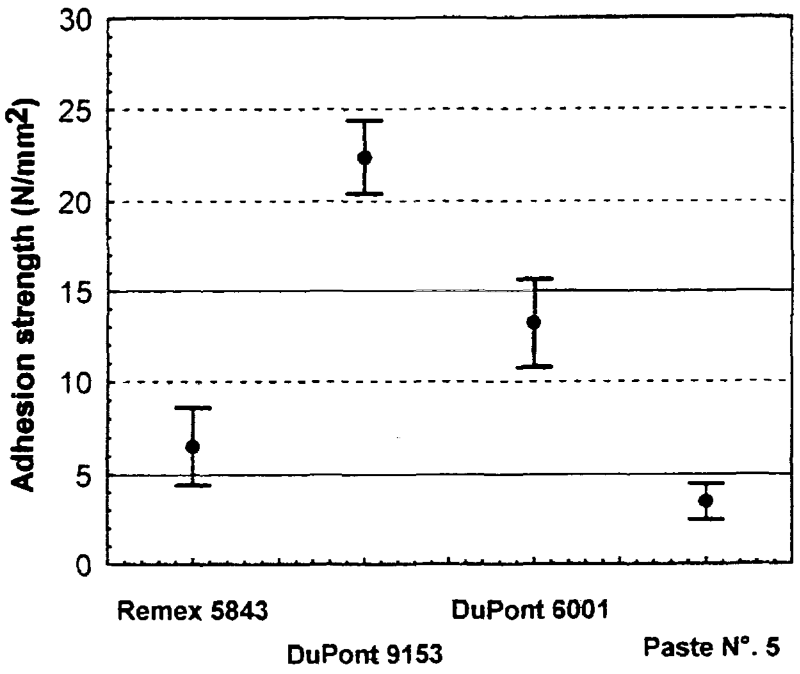

Figure 6: Relationship between adhesion strength of various Cu-thick film metallizations on aluminium nitride (min./max. value)

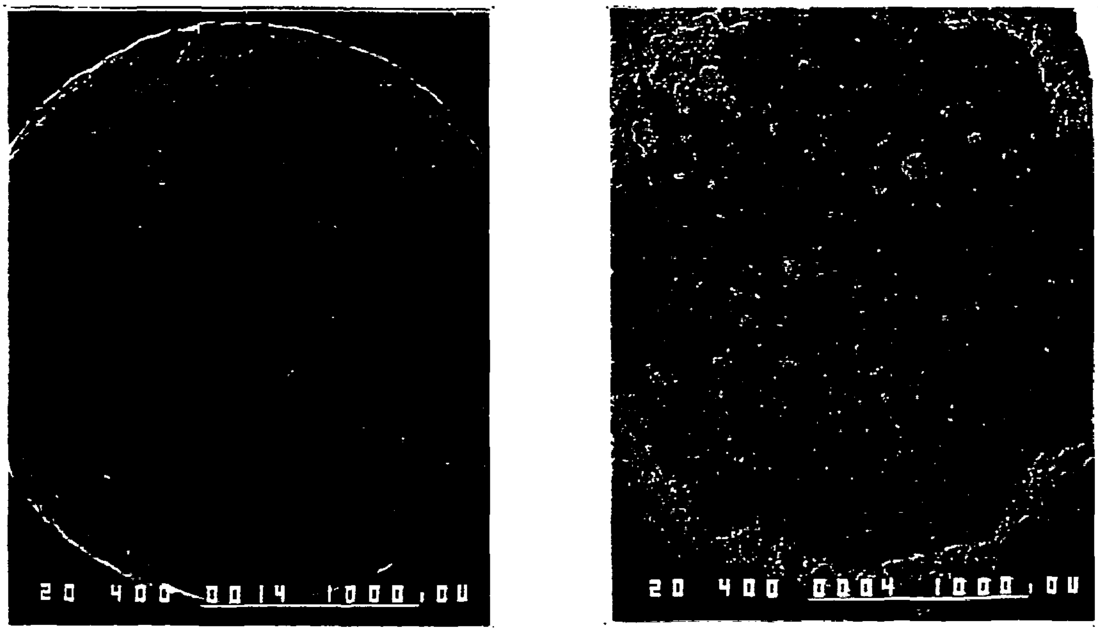

Figure 7: Scanning electron micrograph showing the morphology of fracture from nail-head pin and metallization area after pull-off test (Paste N°.5, 2.5 at% Ti, magnification: 40)

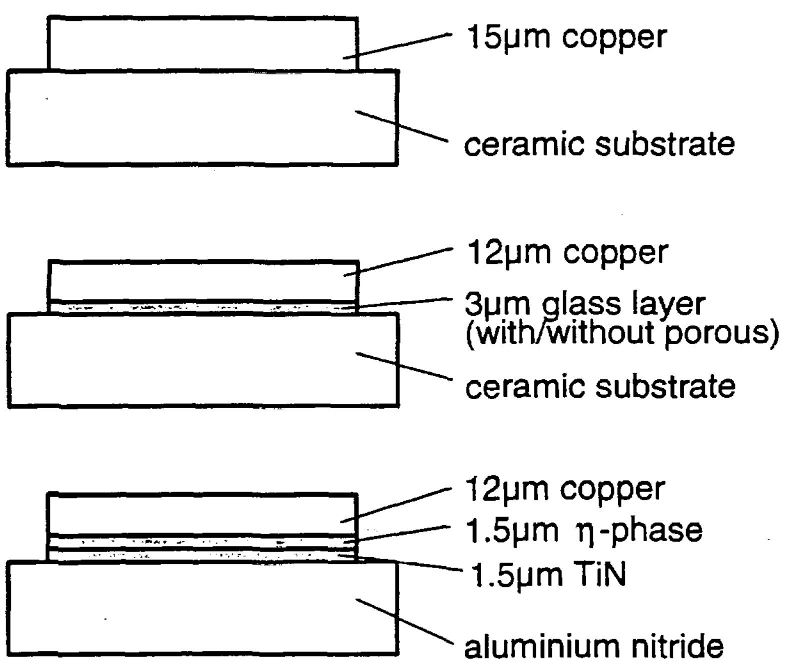

Figure 8: Schematic view of the cross section of different models, used for numerical analysis

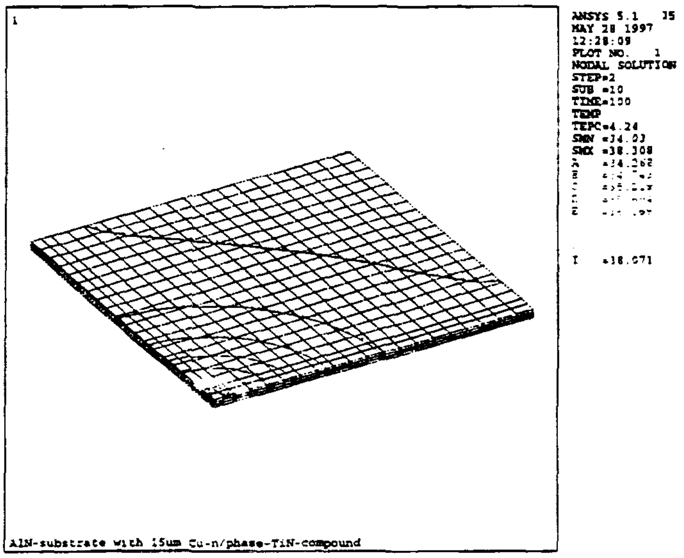

Figure 9a: Three dimensional view of the temperature distribution of an aluminium nitride substrate, loaded with a power of 1 watt, shown after 100 seconds

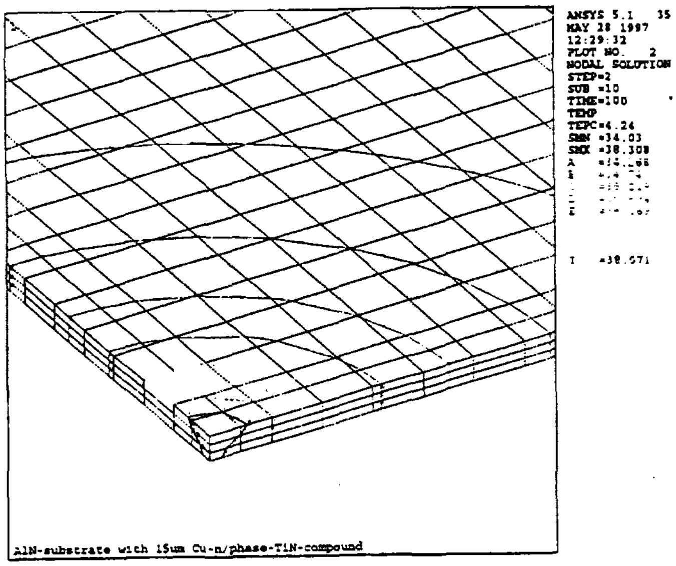

Figure 9b: Detail view of the temperature distribution of metallized area

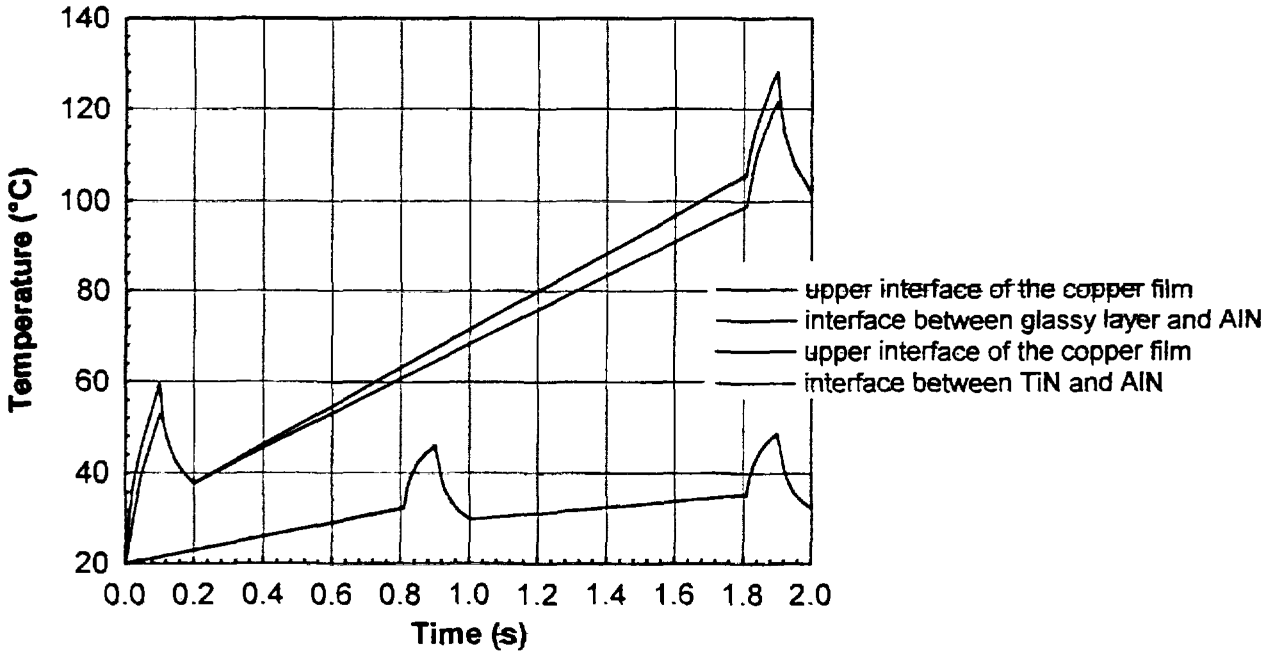

Figure 10a: Relationship between maximum temperature of metallization and time in pulsed mode (5Hz), 12µm copper layer and 3µm glass layer within 50 vol% pores

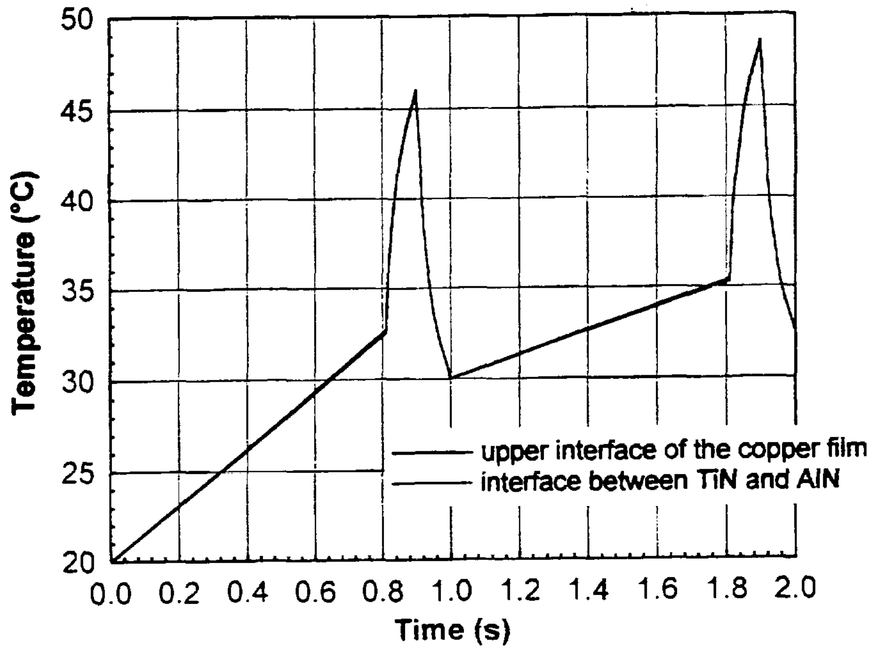

Figure 10b: Relationship between maximum temperature of metallization and time in pulsed mode (5Hz), 12µm copper layer, 1.5µm η-phase and 1.5µm TiN layer

		1 Watt (1e5W/m^2)		10 Watt (1e6W/m^2)	
		Al_2O_3	AlN	Al_2O_3	AlN
15 µm copper-film	T_1/°C	28.79	22.72	107.94	47.16
	T_{100}/°C	58.31	38.14	403.05	201.44
	u_x/µm	2.39	1.83	23.9	18.3
	u_z/µm	0.208	0.0658	2.08	0.658
12 µm copper- and 3µm glass-film	T_1/°C	29.15	22.92	111.51	49.23
	T_{100}/°C	58.47	38.35	404.68	203.52
	u_x/µm	2.39	1.83	23.9	18.3
	u_z/µm	0.207	0.0651	2.07	0.651
12 µm copper- and 3µm glass-film with 50 vol% porous	T_1/°C	29.17	23.25	111.65	52.51
	T_{100}/°C	58.77	38.61	407.74	206.14
	u_x/µm	2.37	1.82	23.7	18.2
	u_z/µm	0.208	0.0675	2.08	0.675
12µm Cu-, 1.5µm h-phase and 1.5µm TiN-film	T_1/°C		22.73		47.68
	T_{100}/°C		38.31		202.75
	u_x/µm				
	u_z/µm				

Table 2: Summary of results from various numerical simulations, electronic device in continuous operation mode