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Auger Microscopy of Laser Induced Fe-oxide/Al Reaction Composite Coating

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A laser-based technique is used to synthesize a Fe_3O_4/Al reaction composite coating on A319Al alloy. The material was analyzed using Scanning Auger Microprobe. The spectroscopy data indicated that several possible stoichiometric compounds formed as a result of chemical reaction between Fe_3O_4 and Al. The elemental composition across the interface region, between such phases and the matrix, changes gradually suggesting that the interface is strong. Presence of Al_2O_3 in close vicinity of Fe-aluminide phase particles and thermodynamic data [1-3] suggests that both Al_2O_3 and Fe have been produced by metallothermic reaction. Fe has further reacted with Al to form Fe-aluminides.

Figure 1 is the secondary electron image of a typical particle-like feature. The Auger elemental analysis suggests that it is a Fe-rich phase. A closer look at the super-imposed line scan (normalized distribution of major elements) plotted across the line in the Fig. 1 indicated constant proportionality between Fe and Al concentration. In addition, the composition across the interface between such aluminide particle and the Al matrix changes gradually also often containing various stoichiometric and nonstoichiometric compositions of aluminides which is an indication of a strong interface. Moreover, such an *in-situ* synthesis of uniformly distributed fine aluminide particles having chemical bonding (via formation of interfacial aluminides) with the matrix are expected to produce the composite coating with superior mechanical properties compared to the Al - substrate.

Table 1 and schematic in Figure 2 summarizes the Auger microprobe results. Un-reacted and fragmented Fe_3O_4 particles were found in the fracture samples. Various reaction products residing near these particles were observed and included stoichiometric and non-stoichiometric phases. The Auger spectroscopy data taken on these phases was reduced to find stoichiometry by taking proportion of major elements present in different combinations for determination of the most likely phases. Fe-oxide particles present were found to have Fe to O atomic ratio between 1.1-1.3. In some particles, Al was present as high as 10 at% suggesting the Al has diffused into the oxide particle but quenched-in before reaction takes place. On the left side of the schematic in Figure 2, a particle like feature is represented. The ratio between Fe to Al was found to decrease gradually across the particle-matrix interface. Several point analysis on interface suggests that they may or may not be stoichiometric compound. The other particle-like features were Al_2O_3.

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Table 1: Summary of Auger spectroscopy data (Metals represents Fe, Al and Si)

Location	Fe:Al	Metals:O	2Al:3O	Possible Stoichiometry	Remark
Particle 1	0.9-1.1	High	6.0-High	FeAl	Possibly stoichiometry is gradually changing
Particle 2	0.75	High	3.6	FeAl (0.75Fe-Al)	
Interface 1	0.66	High	4.9	FeAl (0.66Fe-Al)	
Interface 2	0.34-0.29	High	5.7	$FeAl_3$	
Particle 3	0.41	0.9-1.0	0.58	(Fe,Si,Al)O	Intermediate
Particle 4	0.8-1.0	3-4	1.0-2.0	~	Intermediate
Particle 5	<0.2	>0.8	1-1.1	Al_2O_3	
Particle 6	>3	1.1-1.3	<0.1	Fe_3O_4, FeO	Unreacted
Matrix	0-0.1	<0.05	3-6	~	Alloy

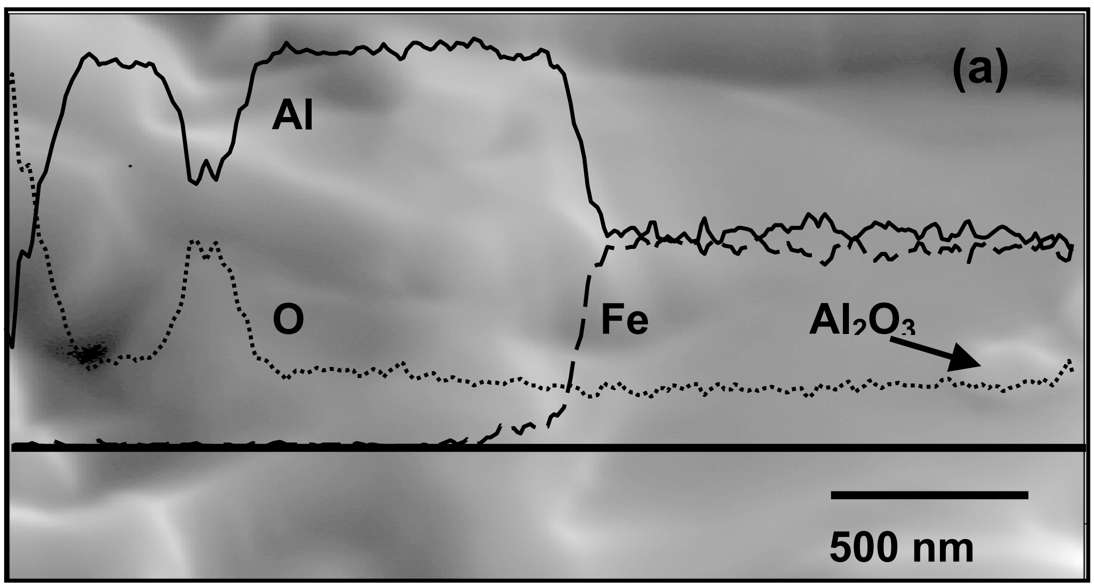

Fig 1: The secondary electron image of a particle like features composing of Fe, Al and O.

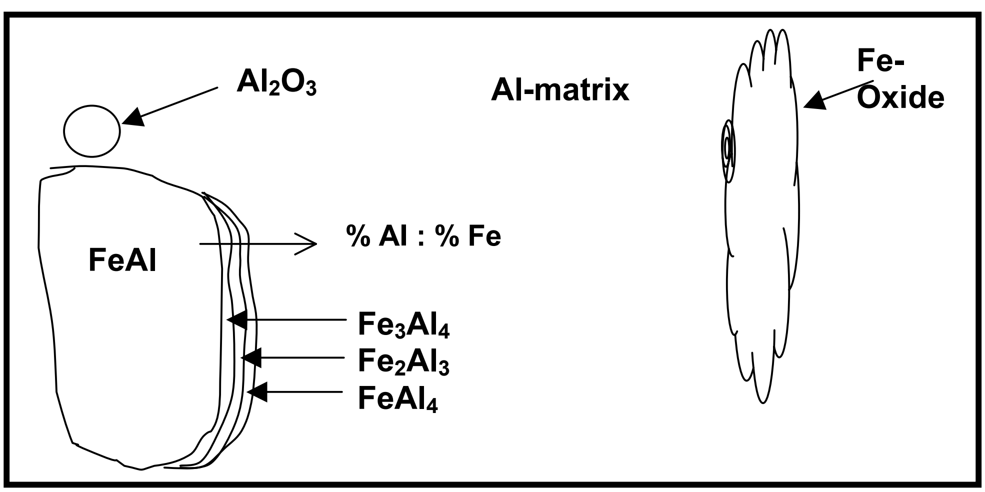

Figure 2: Schematic showing possible stoichiometric phases. Not to scale.

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