



انجمن مهندسين متالورژي ايران  
انجمن علمي ريخته گري ايران  
دانشگاه آزاد اسلامي واحد كرج

همایش ملی مهندسی مواد ، متالورژی و ریخته گری ایران

Al

1×1×1Cm

Ni<sub>3</sub>Al Al<sub>3</sub>Ni NiAl

XRD

SEM

Ni Al

EDS

330min

550<sup>o</sup>c

---

Al

1×1×1Cm

Ni<sub>3</sub>Al Al<sub>3</sub>Ni NiAl

XRD

SEM

Ni Al

EDS

330min

550°c

---

...

. [ ]

. [ ]

[ ]

. [ ]

. [ ]

. [ ]

XRD SEM

[ ]WO<sub>3</sub> PbO [ ]SiO<sub>2</sub> Al

. [ ]

. [ ]

SPEX 8000

. [ ]

[ ]

### مواد و روش تحقیق

1×1×1Cm 99%  
1g  
10μm 99.5%  
200rpm  
Al  
)  
20-50-80- ( / = ) (1.27cm ) (0.95cm  
120-200-300-420-720-1080-1500min  
EDS Oxford EDS (SEM LEO 1450VP )  
XRD  
 $\lambda = 1.5418\text{\AA}$   $c=0.9$  ( $t \lambda / \beta \cos \theta = c$ )  
 $\theta$   $\beta$   
50μm ( Hv 0.025 )  
330min 550°C ( )

SEM  
SEM

420min

Al Ni ( ) (EDS)  
AlNi<sub>3</sub> Al<sub>3</sub>Ni AlNi Ni Al ( )

1500min

Ni-Al

Ni

Ni

(Hv)

Ni

Ni

Al

[ ] Zhaolin Zhan

Ni Al

(660°C) Al

XRD

Ni-Al

Al Al

Ni-Al

Ni

Al Ni

Al

Ni

Al

Al

:

EDS

Al

Al

Ni

( )

Al

Al

( )

[ ]

Jie Meng

Ni-Al

427Hv

Ni<sub>3</sub>Al

NiAl

[ ]

Wang

464Hv

420min

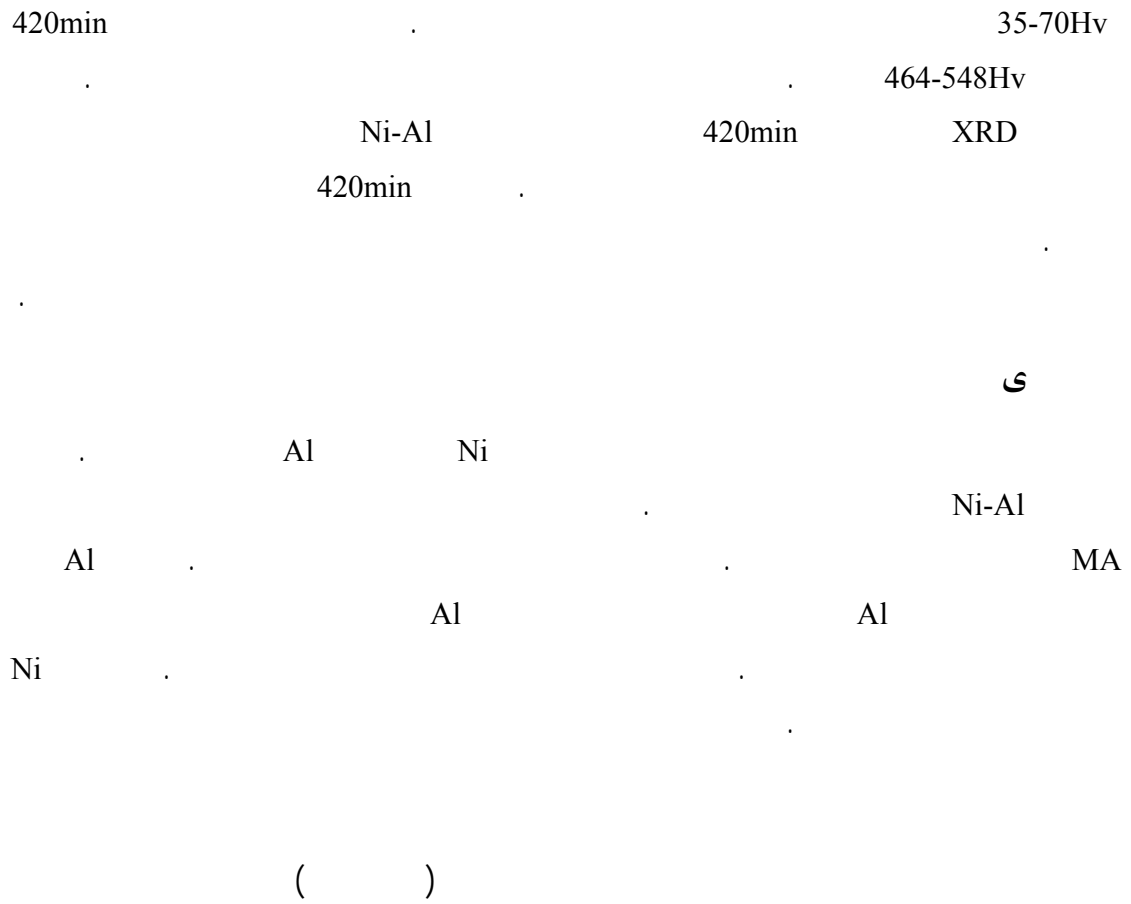
440Hv

Al

Al

420min

550°C

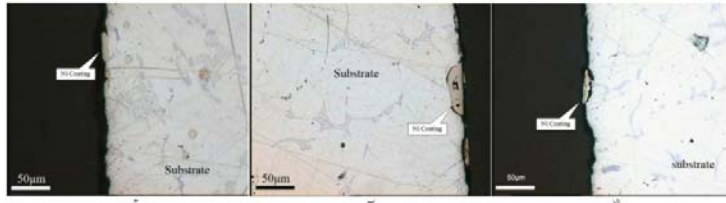


[1] A. Torosyan, J.R. Tuck, A.M. Korsunsky, S.A. Bagdasaryan, Mater. Sci.Forum 386–388 (2002) 229.

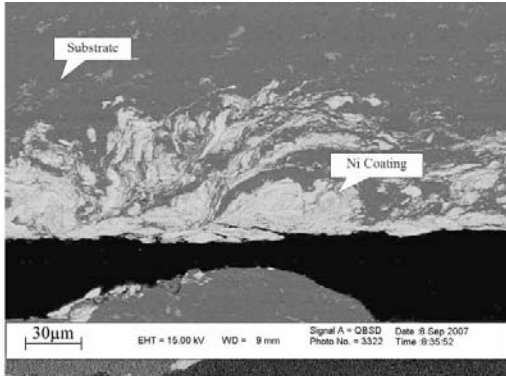
[2] A. Torosyan, L. Takacs, J. Mater. Sci. 39 (2004) 5491.

- [3] A. Torosyan, L. Takacs, L. Zulumyan, A. Tataryan, in: A. Agarwal, N.B. Dahotre, S. Seal, J.J. Moore, C. Blue (Eds.), Surface Engineering in Materials Science III, The Minerals, Metals & Materials Society, Warrendale, PA, 2005, pp. 121–126.
- [4] A. Torosyan, L. Takacs, "Mechanochemical Reaction at the Interface between a Metal Plate and Oxide Powders", *Journal of materials science* 39 (2004) 5491-5496
- [5] Z.B. Wang, N.R. Tao, W.P. Tong, J. Lu, K. Lu, *Acta Mater.* 51 (2003).
- [6] Takacs, L., Revesz, A., "Preparation of Coatings by Mechanical Alloying", *Chemistry of sustainable Development* 15 (2007) 231-235
- [7] S. E. Romankov, S.D. Kaloshkin and L. U. Pustov. 12<sup>th</sup> Int. Symp. on Metastable and Nanomaterials (ISMANAM), July 3-7, 2005, Paris, France, paper P1-87
- [8] L. Takacs and A. Torosyan, 12<sup>th</sup> Int. Symp. on Metastable and Nanomaterials (ISMANAM), July 3-7, 2005, Paris, France, paper 7C-I-1.
- [9] Zhan Zh., Y. He, D. Wang, W. Gao, "Low-temperature processing of Fe–Al intermetallic coatings assisted by ball milling", *Science direct intermetallics* 14 (2006) 75-81
- [10] Jie, M., Chengchang, J., Qing, H., "Effect of mechanical alloying on the structure and property of Ni<sub>3</sub>Al fabricated by hot pressing", *Journal of Alloys and Compounds* 421 (2006) 200–203
- [11] Wang, Y., Chen, W., "Microstructures, Properties and High-Temperature Carburization Resistances of HVOF Thermal Sprayed NiAl Intermetallic-based Alloy Coatings", *Surface and Coatings Technology* 183 (2004) 18–28

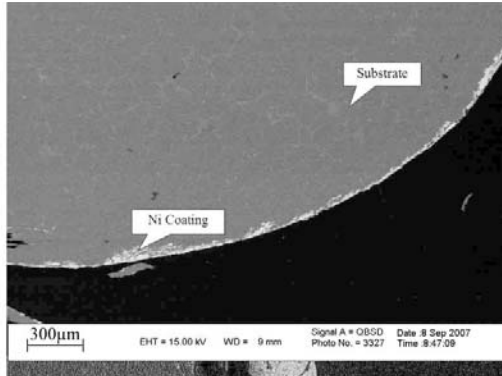




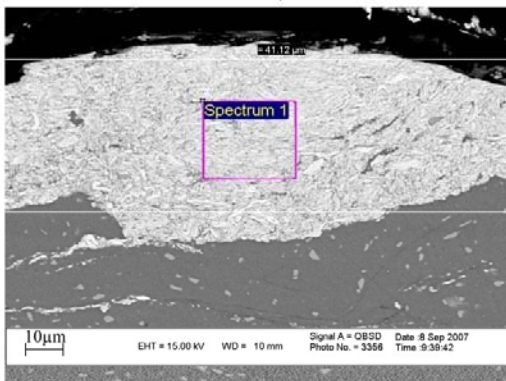
. 80min ( ) 50min ( ) 20 min ( ) Ni



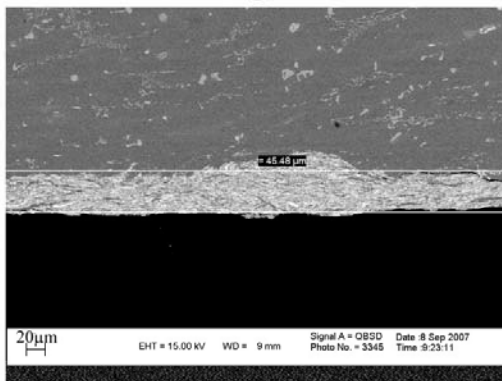
ب



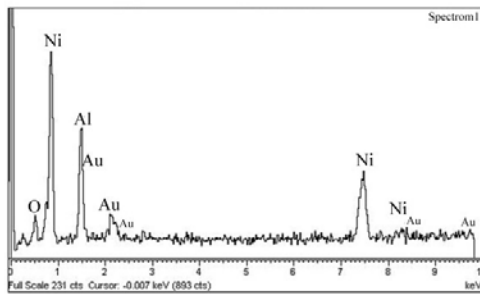
الف



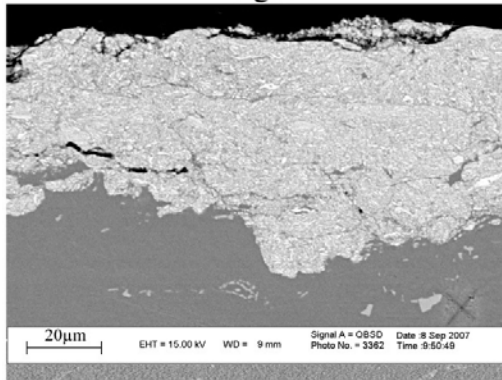
د



ج



س



ه

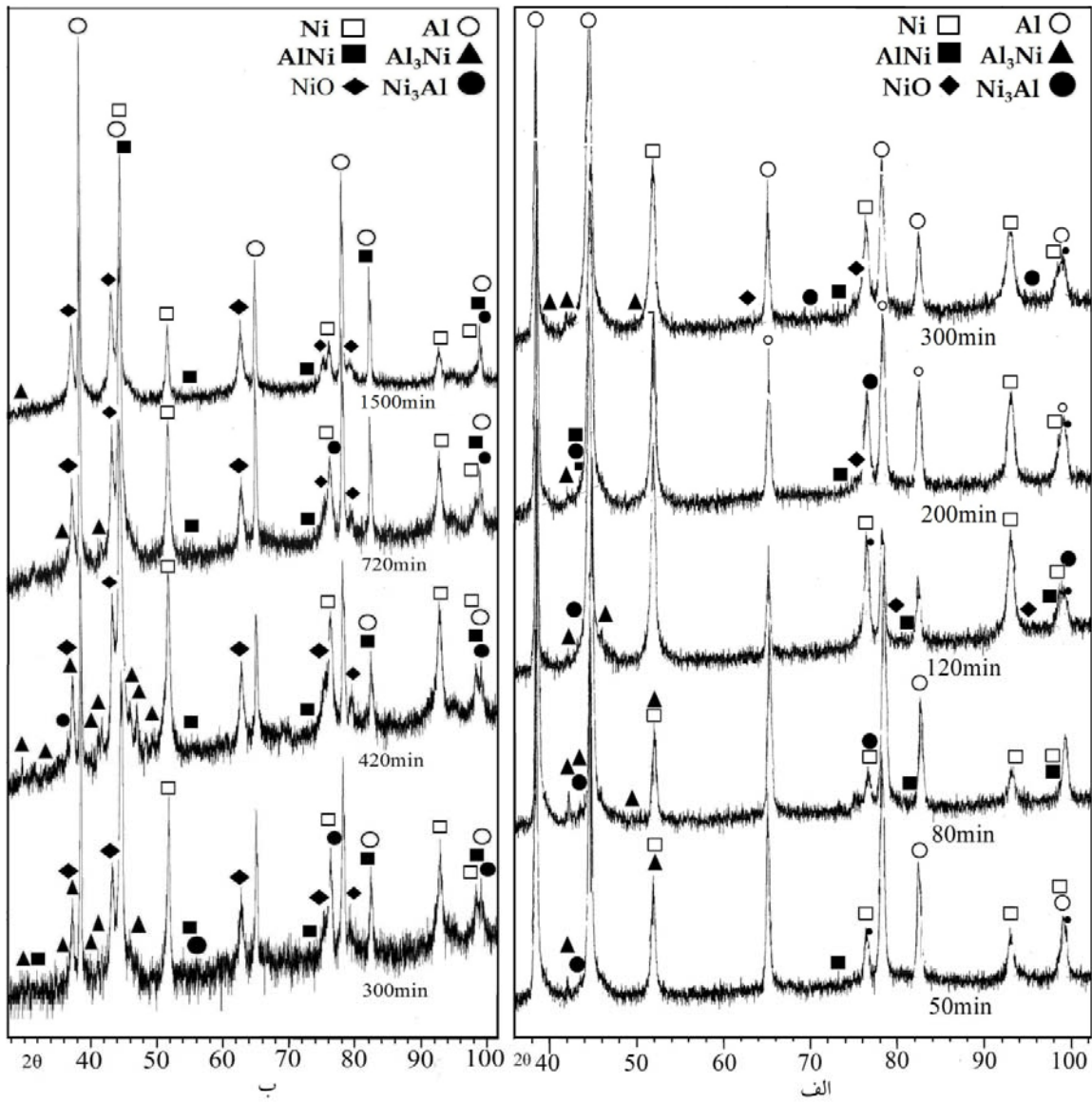
720min( 420min ( 300min( 120min(

SEM

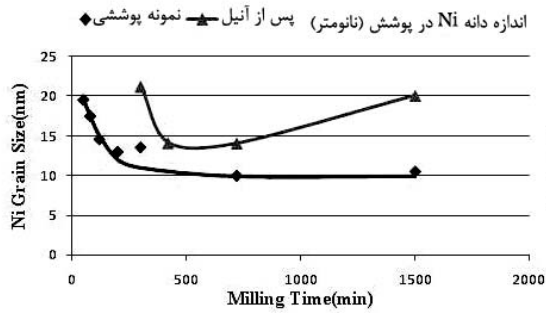
. EDS (

Ni-Al

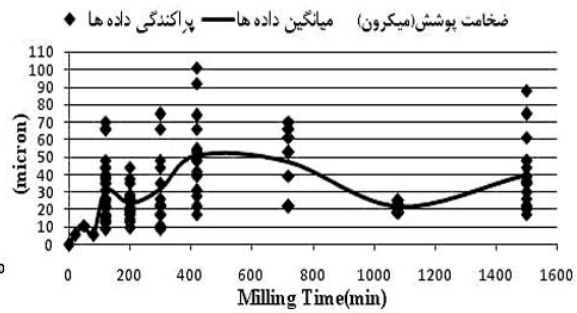
|                                       | Ni <sub>3</sub> Al | Al <sub>3</sub> Ni | NiAl     |
|---------------------------------------|--------------------|--------------------|----------|
| $\Delta H_f (298^\circ) (j.mol^{-1})$ | -153.134           | -150.624           | -118.407 |



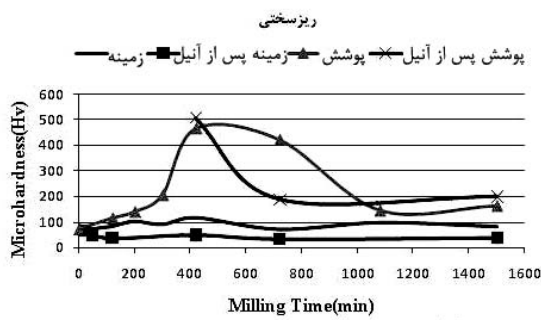
( . ( Ni 1g  
 . 330min 550°C



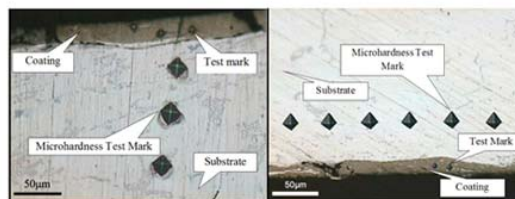
شکل ۵- اندازه دانه‌های Ni پوشش داده شده روی سطح Al با گذشت زمان آسیاکاری در دو حالت قبل از آنیل و پس از آنیل.



شکل ۴- ضخامت نمونه‌های پوشش داده شده با Ni با زمان آسیاکاری



شکل ۷- تغییرات ریزسختی زمینه و پوشش قبل و پس از آنیل



شکل ۶- آزمایش ریزسختی از نمونه‌های پوششی الف) 420min آسیاکاری شده ب) 1500min آسیاکاری و آنیل شده.

## Mechanochemical Coating on the Metal Plates by Mechanical Alloying Method

Pouriamanesh, R.<sup>1</sup> Vahdati, J.<sup>2</sup> Yousefi, A.<sup>3</sup>.

[R\\_pouria2000@yahoo.com](mailto:R_pouria2000@yahoo.com) , [vahdati@um.ac.ir](mailto:vahdati@um.ac.ir) , [ayo799@mail.com](mailto:ayo799@mail.com)

### Abstract

Aluminum alloy substrate was coated by nickel powder by means of mechanical alloying (MA) method. Aluminum samples were in the form of cubic with 1×1×1cm dimensions which were ball-milled with nickel powder in a planetary ball-mill. During the mechanoactivation processing, the substrate surface was impacted by some flying balls along with particles of powder. The surface was hardened and activated as a result of the high-energy impact of balls. Ni-Al intermetallic phases were formed in the coating layer. Formation of such intermetallic phases increases the local temperature, which causes a better adherence of the nano-sized coat to the substrate. Coated samples were annealed at 550°C for 330min. Vickers microhardness measurement was performed on both substrate and coating. The microstructure of samples was also investigated by SEM and optical microscope. Chemical composition was analyzed by energy dispersive X-ray spectroscopy (EDS). The final structure was studied by X-ray diffraction (XRD) analysis.

Key words: Mechanical alloying , mechanoactivation, coating , intermetallic

---

1-Master of Science student – The department of Metallurgy and Material Engineering – Engineering Faculty – Ferdowsi University of Mashhad, Iran. [Tel:09153050383](tel:09153050383)

2-Professor - The department of Metallurgy and Material Engineering – Engineering Faculty – Ferdowsi University of Mashhad, Iran. [Tel:05118763305](tel:05118763305)

3- Ph.D degree – Pare Tavoos Research Institute – Mashhad, Iran. [Tel: 05115420731](tel:05115420731)

