INVESTIGATION OF NOVEL ALLOY $TiC\text{-}Ni\text{-}Ni_3Al$ FOR SOFC INTERCONNECT APPLICATIONS

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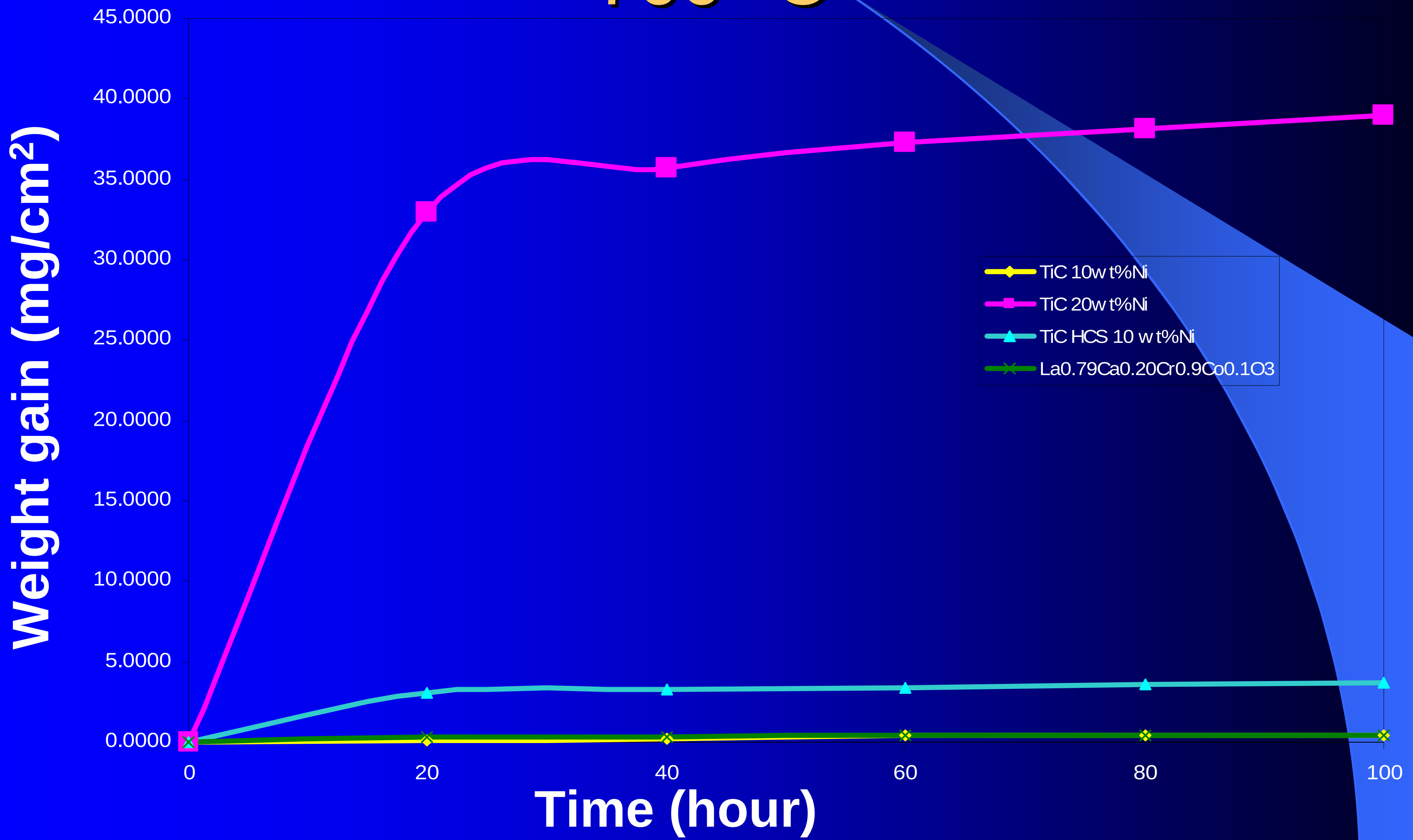
Weight gain in air for 100 hours at 700 °C

	Materials	Weight gain after 20hr (mg/cm^2)	Weight gain after 40hr (mg/cm^2)	Weight gain after 60hr (mg/cm^2)	Weight gain after 80hr (mg/cm^2)	Weight gain after 100hr (mg/cm^2)
1	TiC 30C 10Ni	0.1446	0.2603	0.3759	0.4338	0.4338
2	TiC 34C 20Ni	32.9063	35.6809	37.2368	38.1444	38.9482
3	TiC HCS 10Ni	3.0882	3.2582	3.4282	3.5415	3.7115
4	$La_{0.79}Ca_{0.20}Cr_{0.9}Co_{0.1}O_3$	0.3202	0.3629	0.3843	0.3843	0.4483

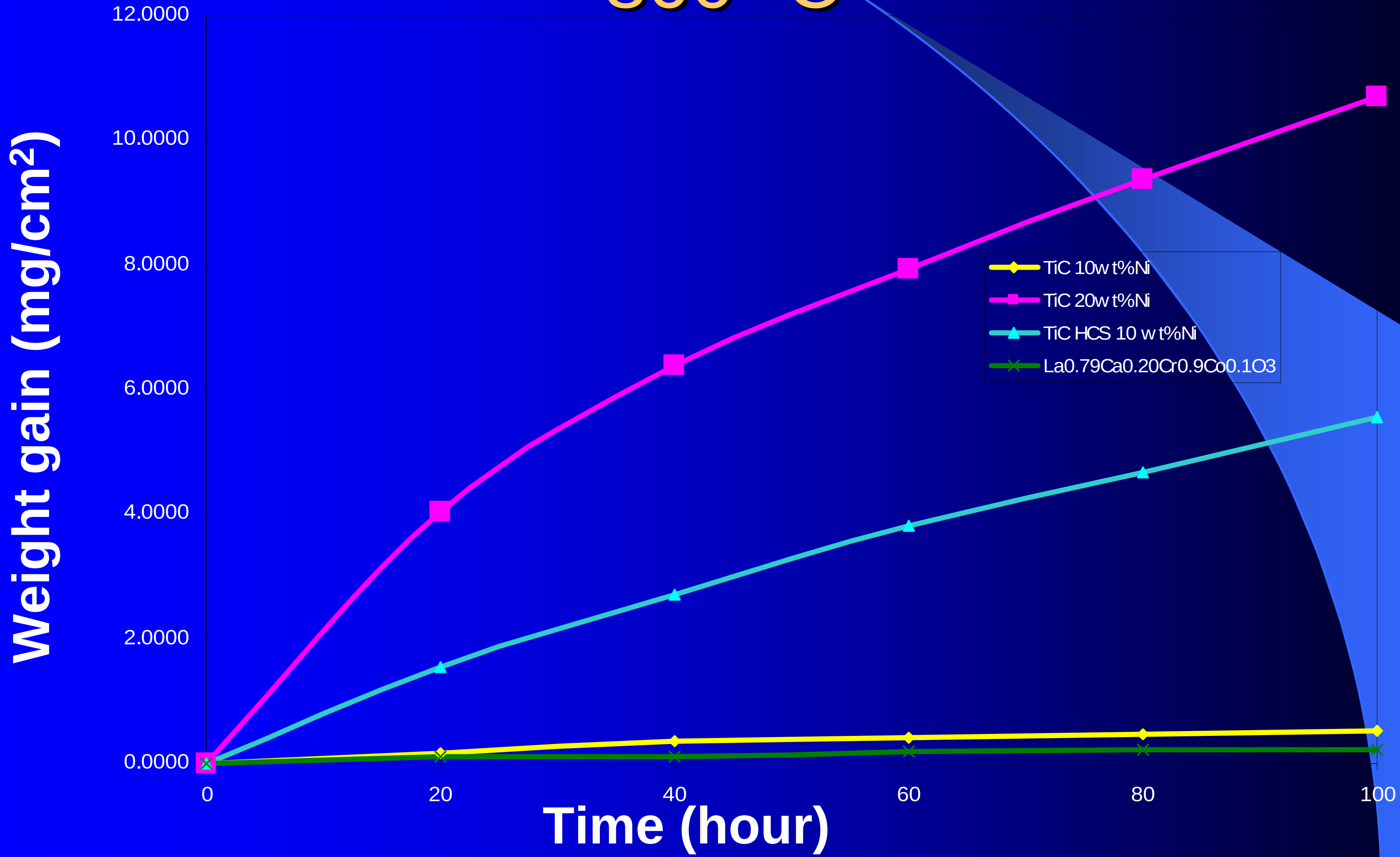
Weight gain in air for 100 hours at 700 °C



Weight gain in air for 100 hours at 800 °C

	Materials	Weight gain after 20hr (mg/cm^2)	Weight gain after 40hr (mg/cm^2)	Weight gain after 60hr (mg/cm^2)	Weight gain after 80hr (mg/cm^2)	Weight gain after 100hr (mg/cm^2)
1	TiC 30C 10wt%Ni	0.1735	0.3470	0.4048	0.4627	0.5205
2	TiC 34C 20wt%Ni	4.0452	6.3790	7.9349	9.3870	10.7090
3	TiC HCS 10wt%Ni	1.5583	2.7199	3.8248	4.6748	5.5530
4	$La_{0.79}Ca_{0.20}Cr_{0.9}Co_{0.1}O_3$	0.1067	0.1067	0.1921	0.2135	0.2348

Weight gain in air for 100 hours at 800 °C



Weight gain in air for 100 hours at 800 °C

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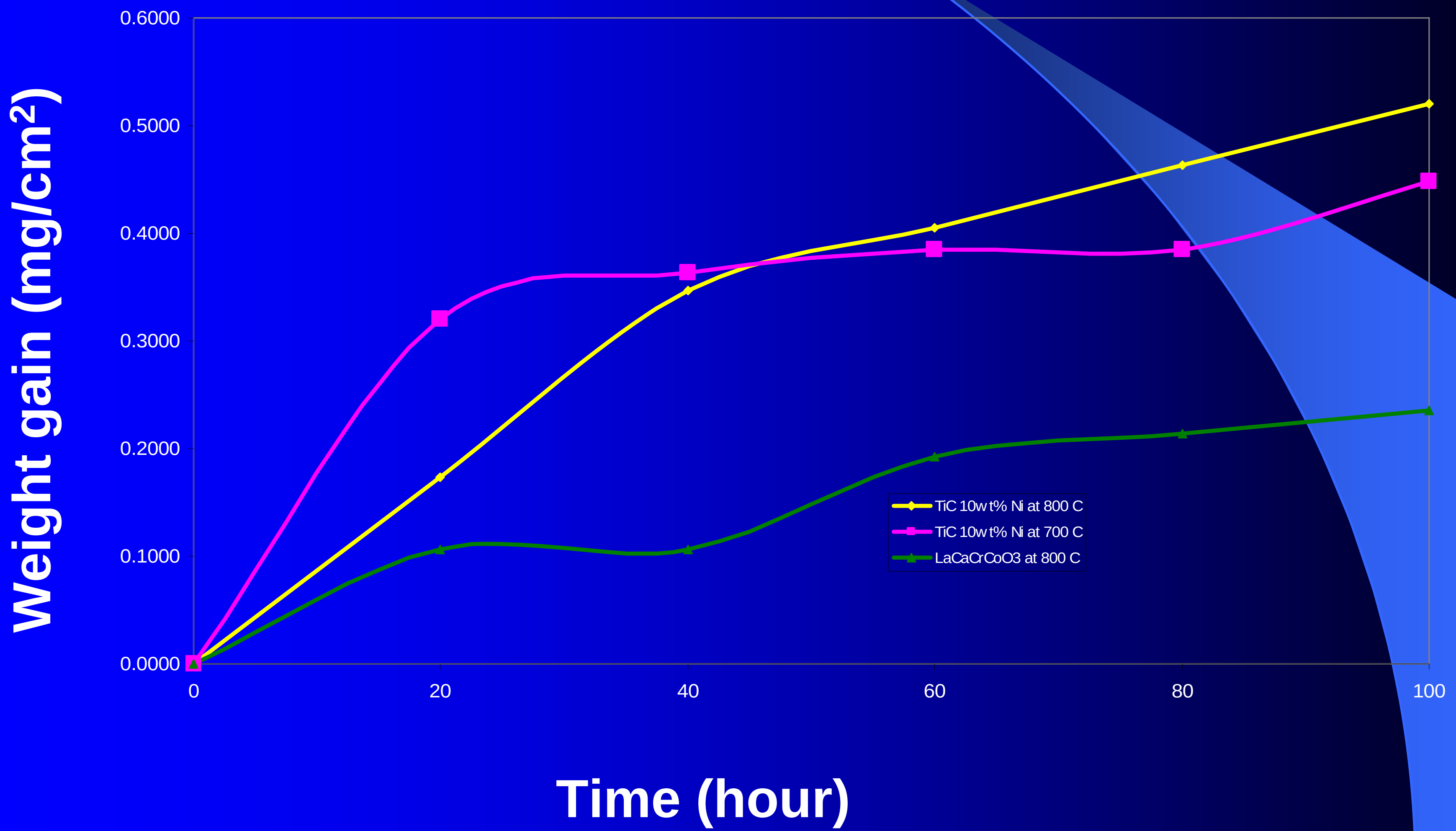
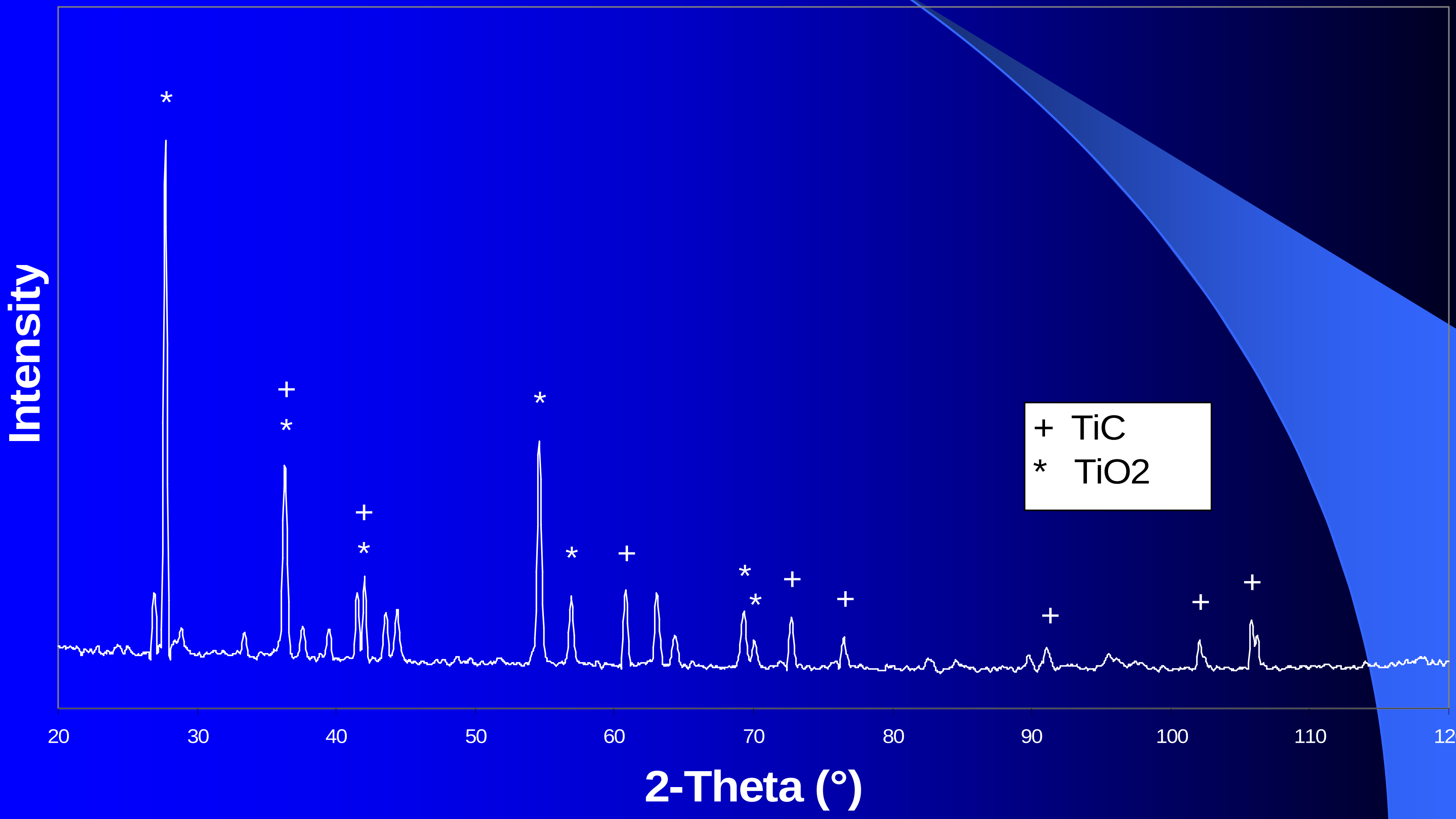
4	$La_{0.79}Ca_{0.20}Cr_{0.9}Co_{0.1}O_3$	0.1067	0.1067	0.1921	0.2135	0.2348
5	K Hp TiC-Ni_3Al	1.5219	2.6814	3.638	4.4642	5.2613
6	HCS 40vol%NA	1.6369	2.9492	3.9367	4.7620	5.4790
7	Koc 40vol%NA	2.1219	3.4423	4.4954	5.3913	6.1772
8	HCS Hp 60TiC 40vol%Ni_3Al	7.0593	8.9634	10.6353	11.7500	12.9575
9	Tic 29.5 25wt%Ni	15.1486	19.8707	22.6596	24.7512	26.4309
10	Tic 29.5 25wt%Ni_3Al	19.0913	27.4278	31.5006	33.9188	35.7006

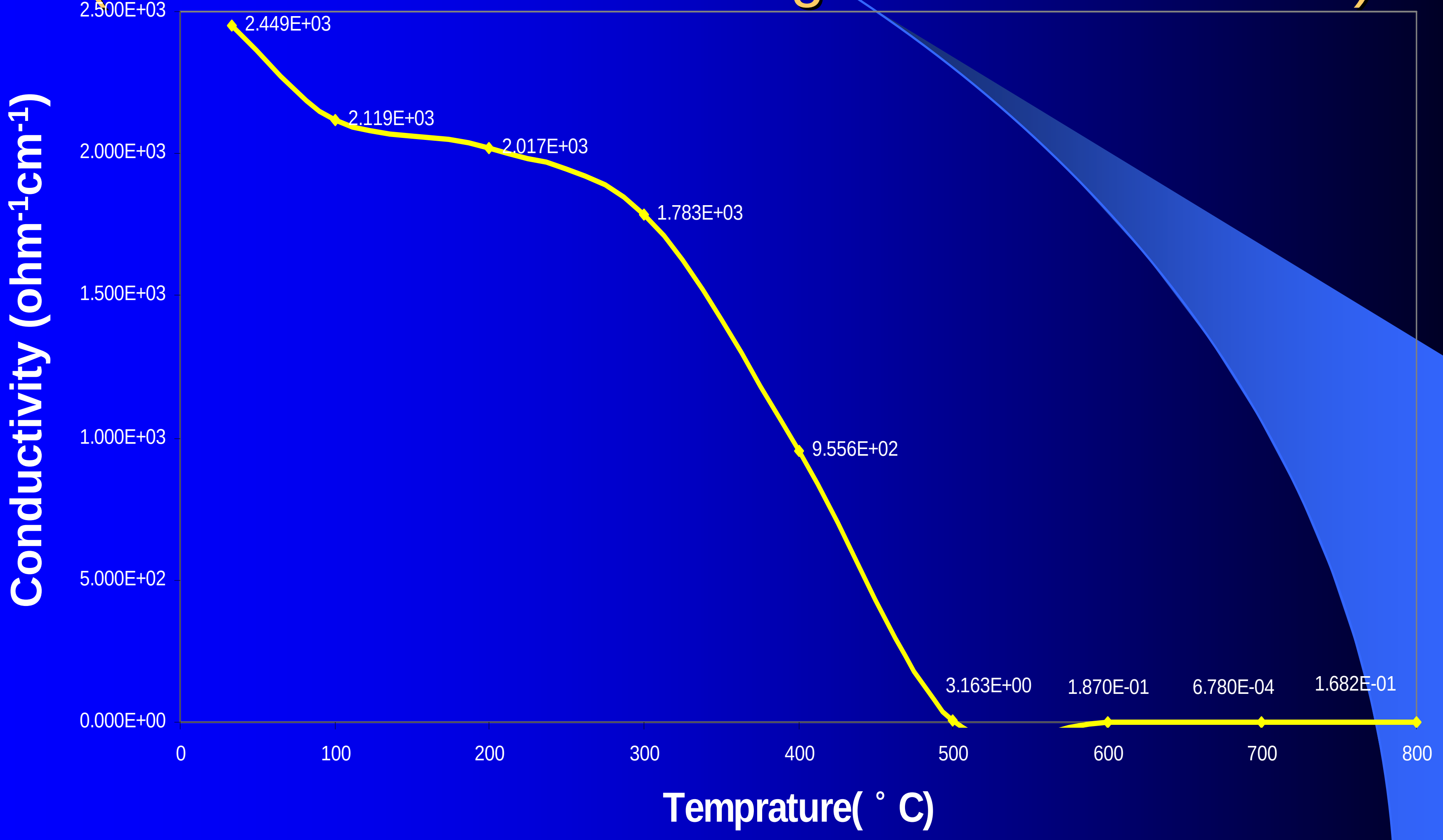
Weight gain of TiC 10wt% Ni in air at 700 °C and 800 °C



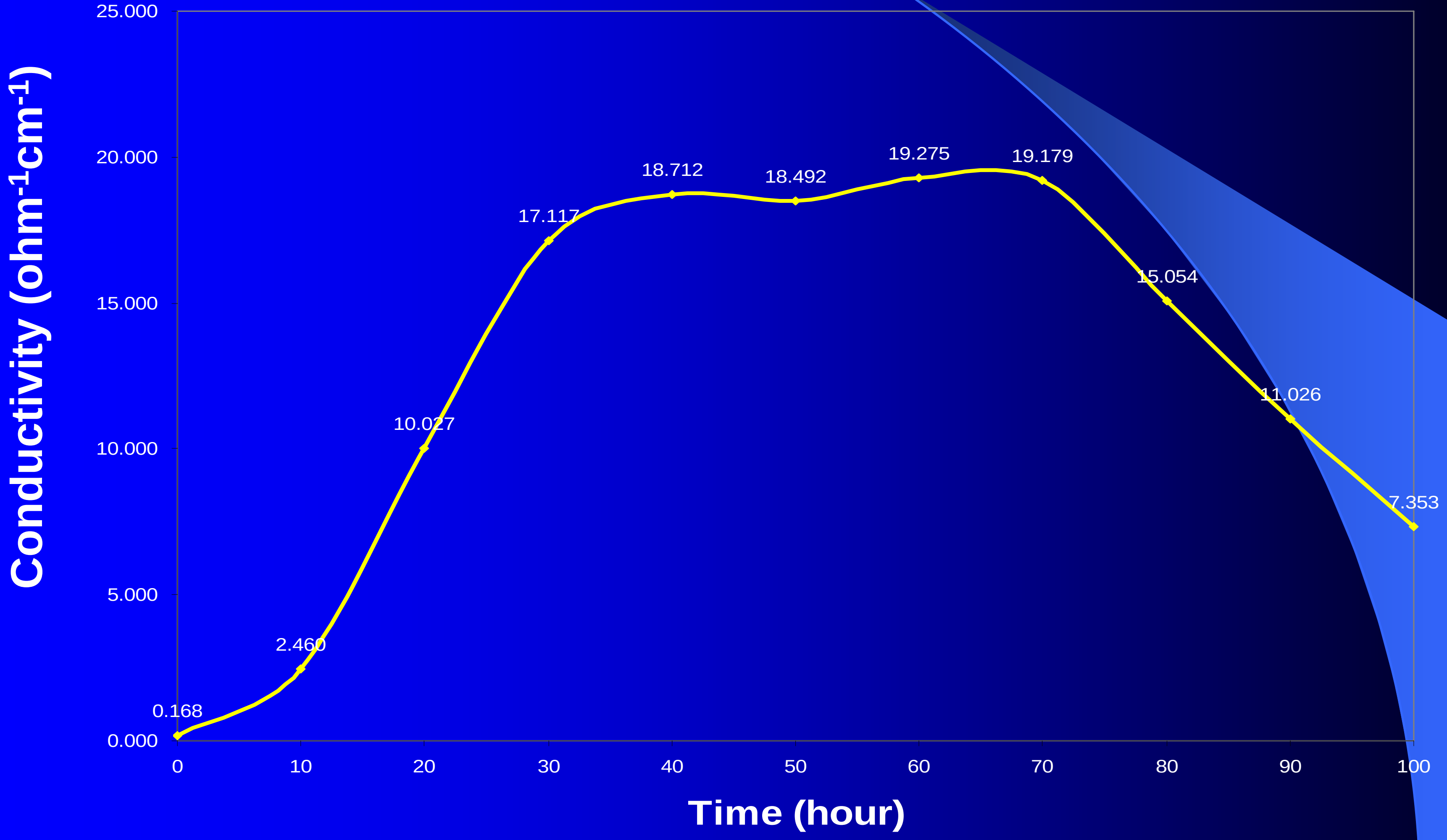
Surface XRD of TiC 10wt% Ni oxidized for 100 hrs at 700˚C plus 100hrs at 800 ˚C



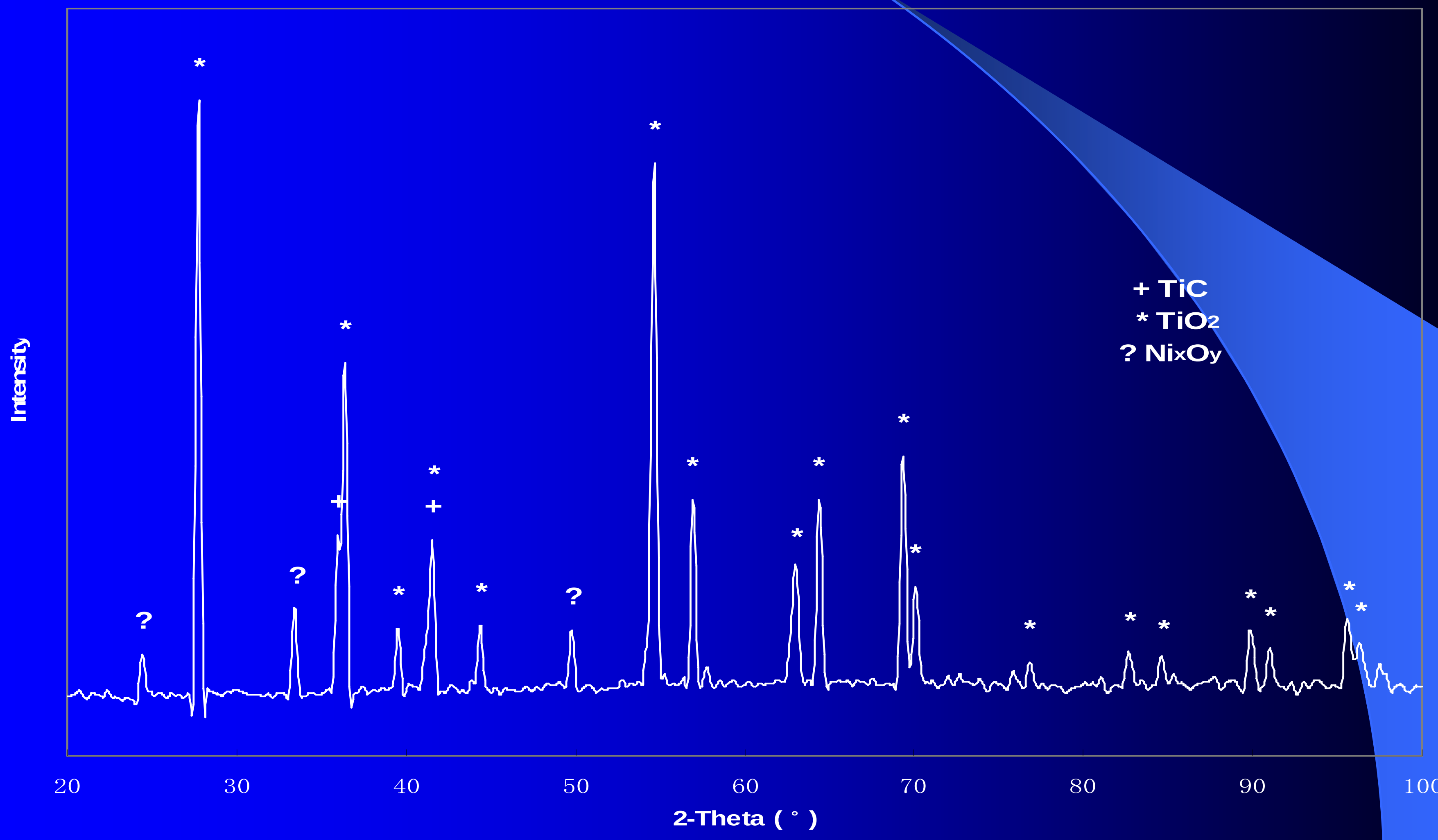
Electrical conductivity of TiC 30wt%Ni at 23˚C-800˚C
(Total time 25 hours during the measurements)



Electrical conductivity of TiC 30wt%Ni at 800°C



Surface XRD of TiC 30wt% Ni oxidized for 100 hrs at 800 °C (after the conductivity measurements)



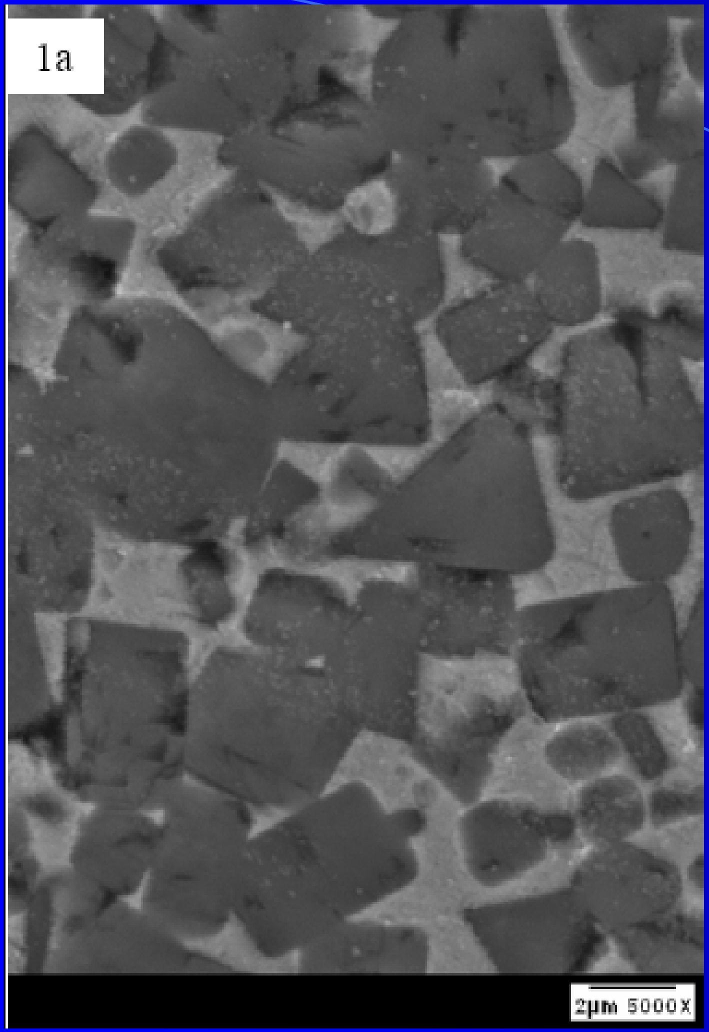


Figure 1a. TiC-30Ni internal (polished) microstructure after oxidation

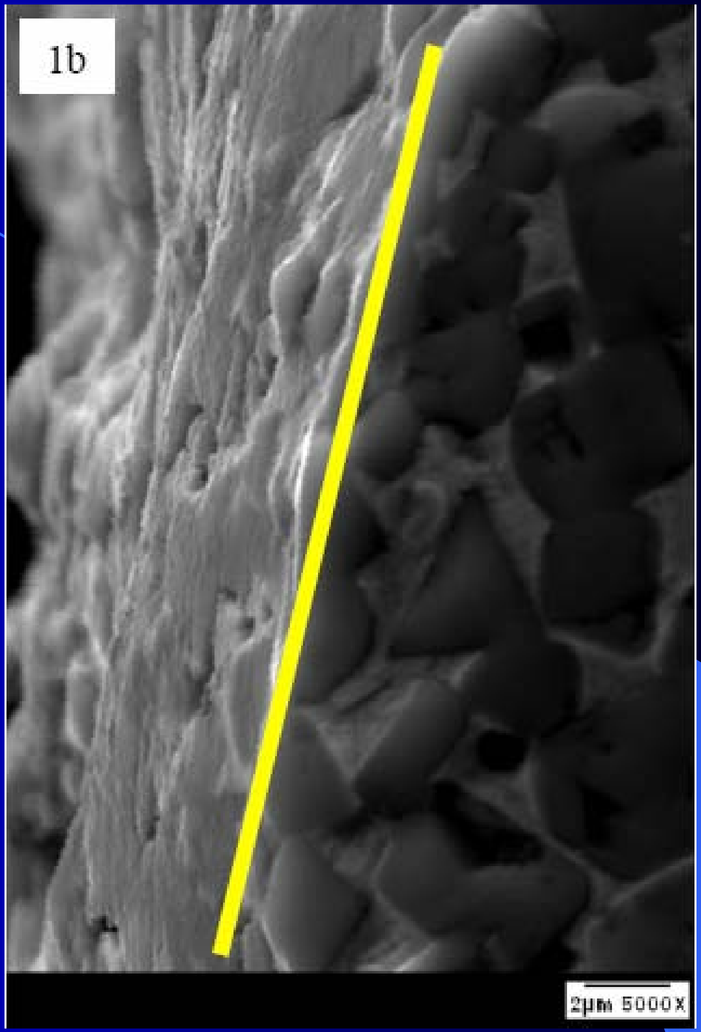


Figure 1b. TiC-30Ni oxidized and polished surfaces. Right of the line is the polished internal surface, left of line is oxidized surface. Grains (and open pores) are visible within the oxidized layer

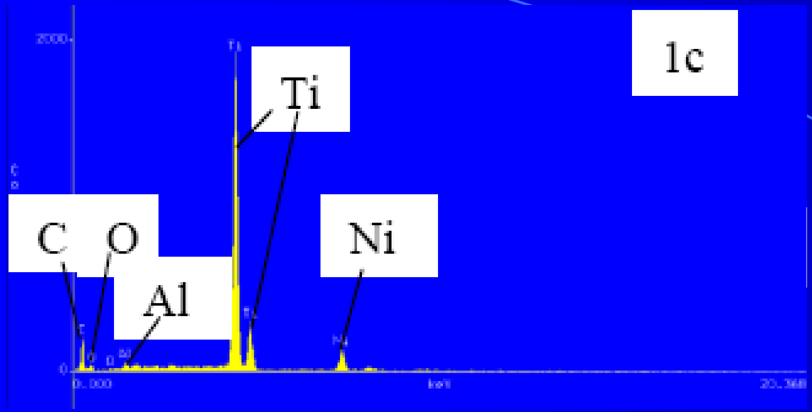


Figure 1c. EDX spectrum from TiC-30Ni sample surface after oxidation. Comparing this data with the untested spectrum shows that an oxygen (O) peak has appeared (left near the carbon (C) peak). Spectrum shows both Ti and Ni, though the latter appears similar to untested TiC grain spectrum. This might indicate that the surface layer is a titanium oxide and not a nickel oxide. Al peak is either from the sample holder or from the polishing media.

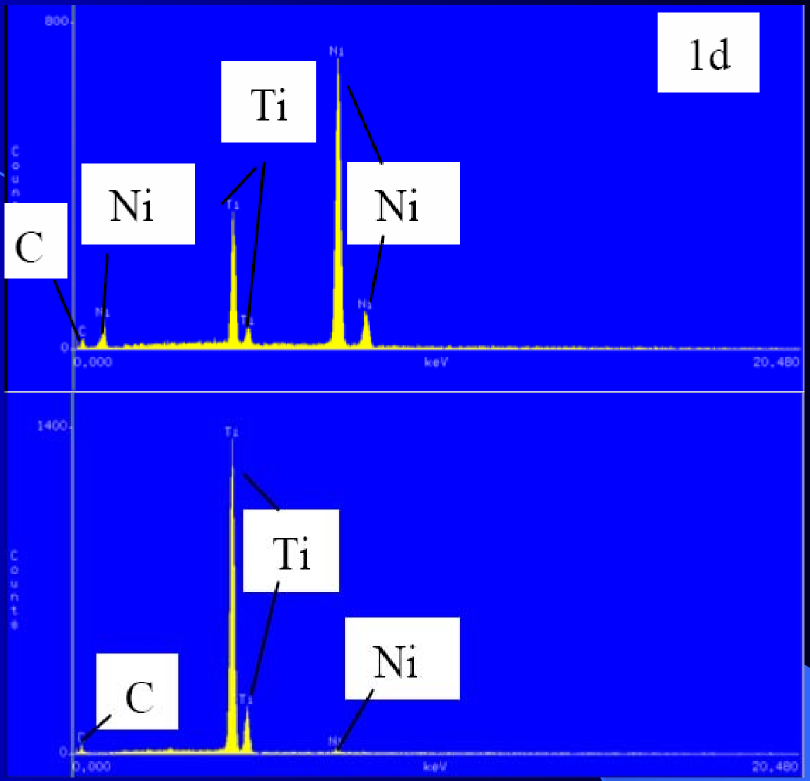
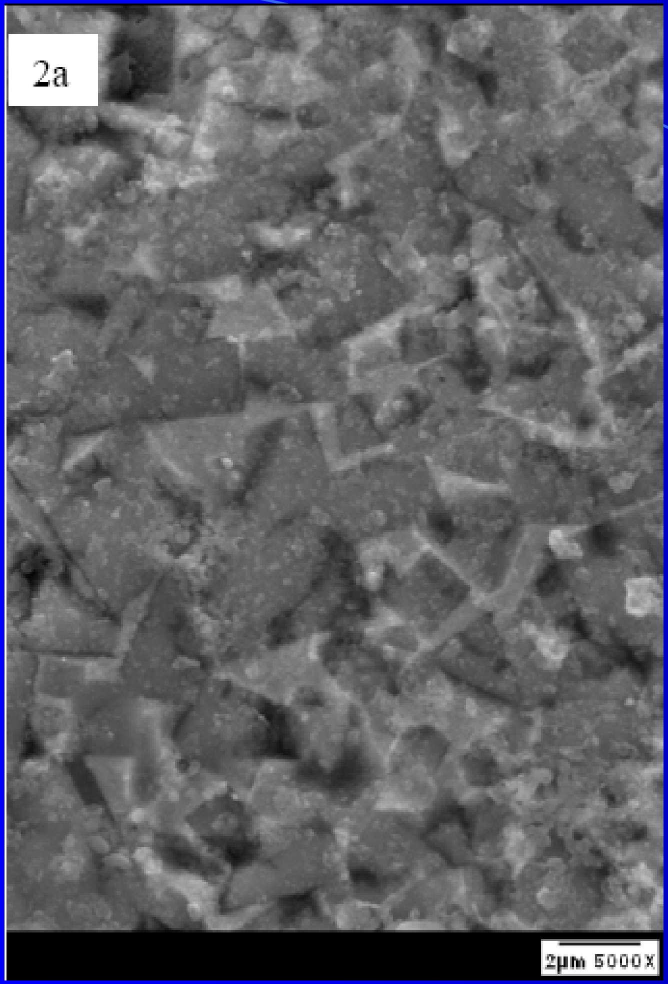


Figure 1d. EDX spectra from untested sample. Top spectrum is from Ni region, bottom spectrum from TiC grain.



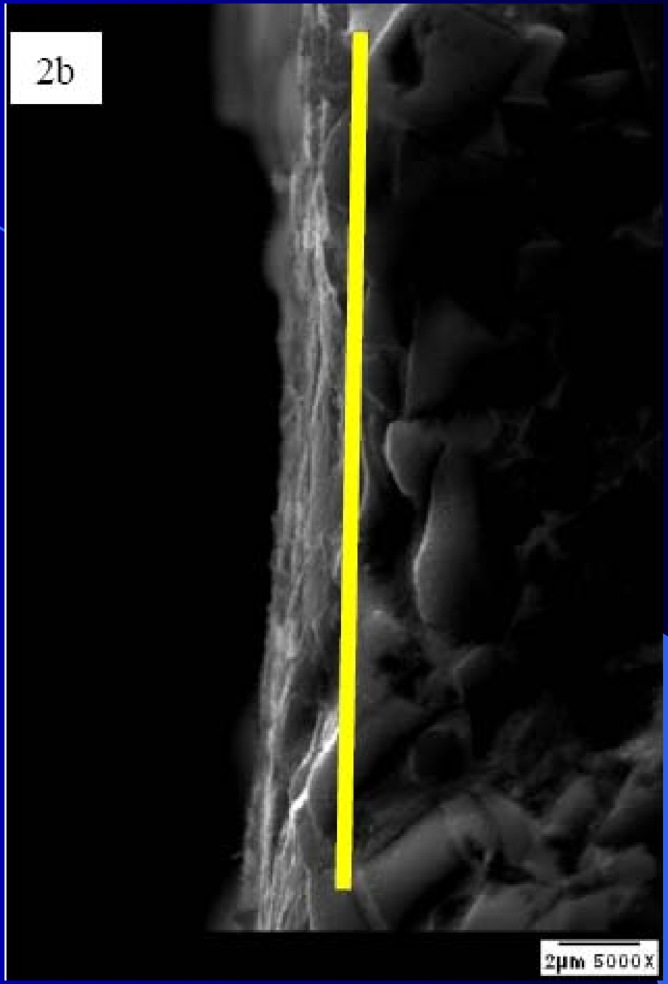


Figure 2a. TiC-30Ni_3Al internal (polished) microstructure after oxidation

Figure 2b. TiC-30Ni_3Al oxidized and polished surfaces. Right of the line is the polished internal surface, left of line is oxidized surface. Grains (and open pores) are visible within the oxidized layer.

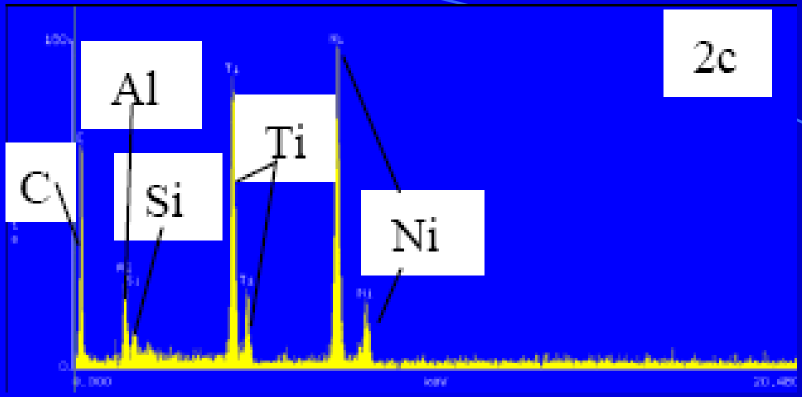


Figure 2c. EDX spectrum from TiC-30Ni_3Al sample surface after oxidation. Unlike the 30Ni sample, no oxygen (O) peak is apparent, indicating perhaps that the content is too low relative to the detected elements. The Al peak is expected, but of greater intensity than for the untested sample. This increased intensity, along with the detected Si peak, likely is due to the polishing media. As SiC was used, this might also explain the higher C peak intensity.

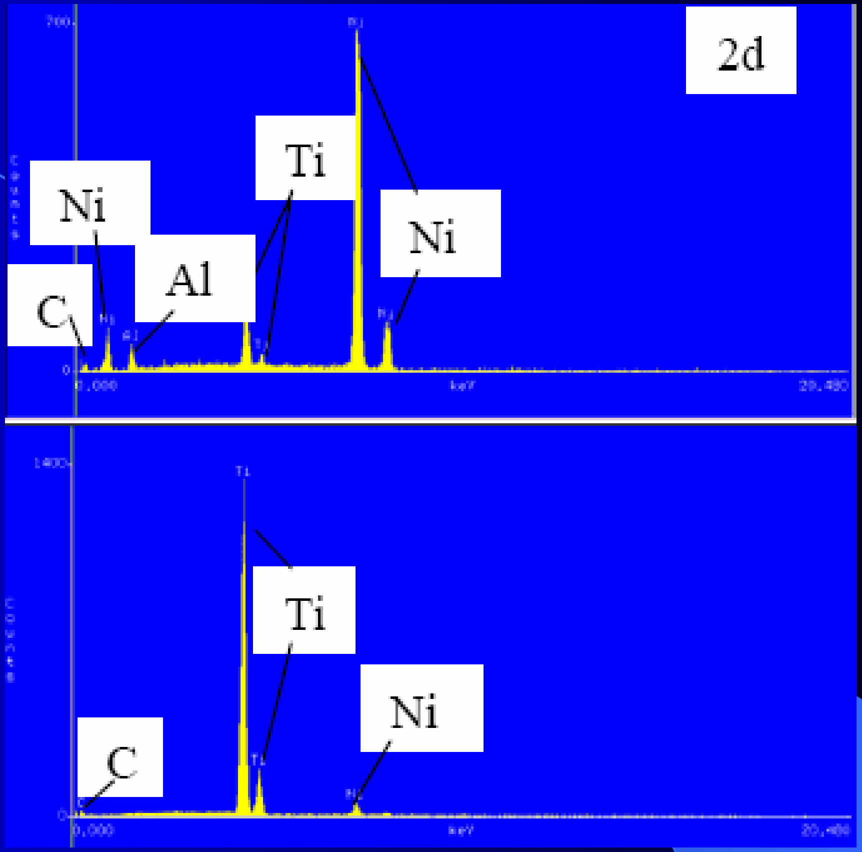
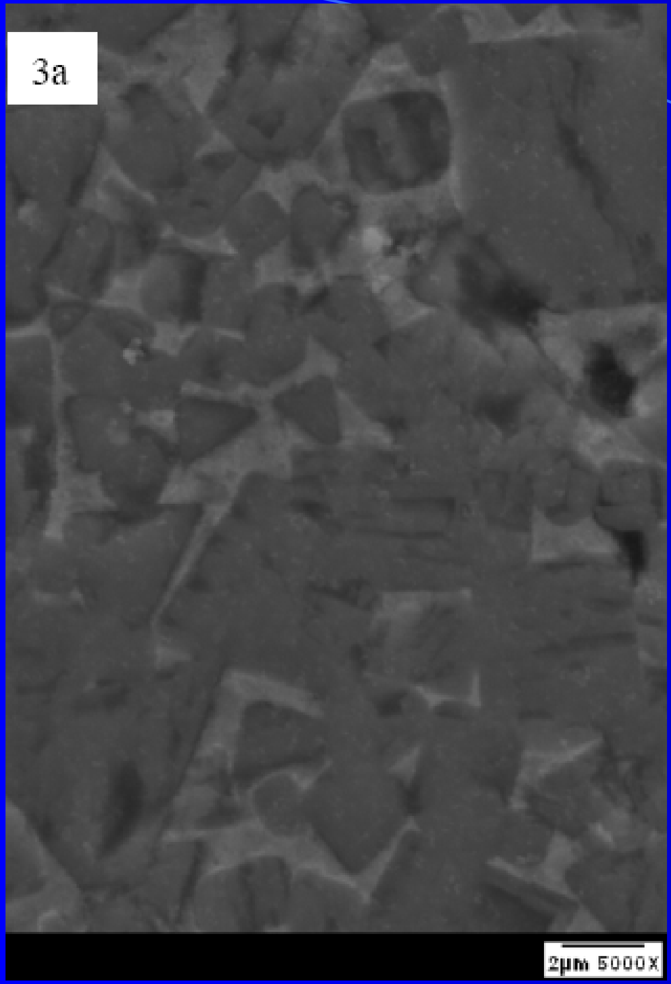


Figure 2d. EDX spectra from untested sample. Top spectrum is from Ni3Al region, bottom spectrum from TiC grain.



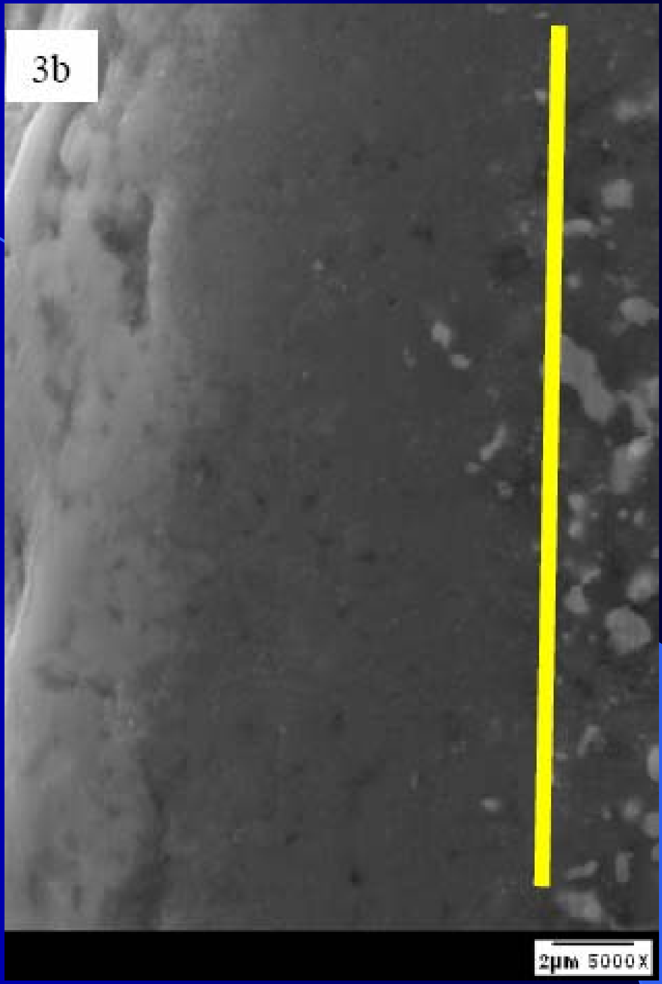


Figure 3a. TiC-25Ni internal (polished) microstructure after oxidation

Figure 3b. TiC-25Ni oxidized and polished surfaces. Right of the line is the polished internal surface, left of line is oxidized surface. This layer is much thicker than that of the 30wt% Ni sample (Fig. 1b) after subjection to the same conditions.

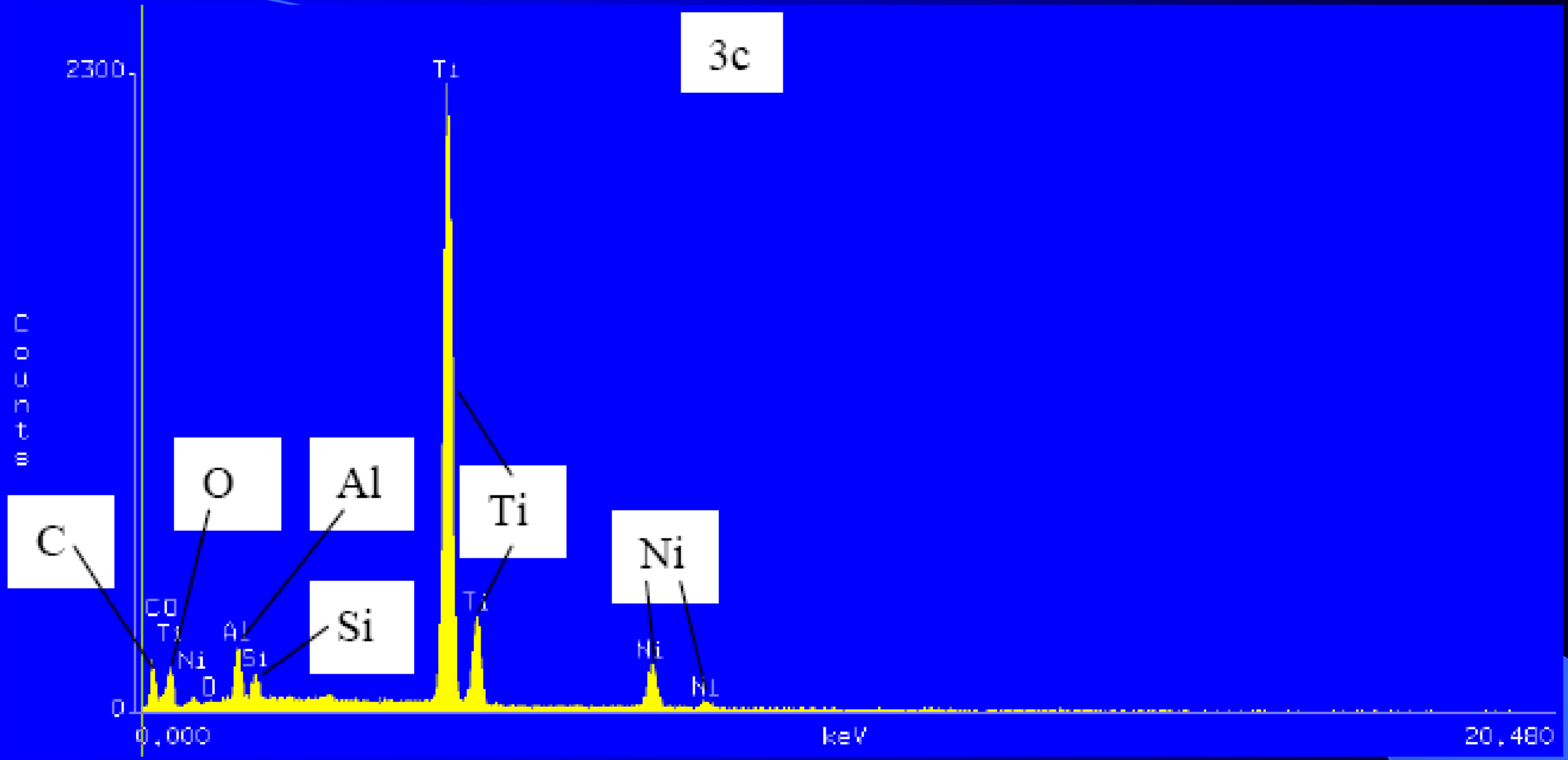


Figure 3c. EDX spectrum from TiC-25Ni sample surface after oxidation. Ti is the primary element present, with slight Ni detected. Again, the polishing media give rise to peaks from Al and Si. There is a more notable peak for O, at low keV. This might indicate that oxides of Ti are prevalent.

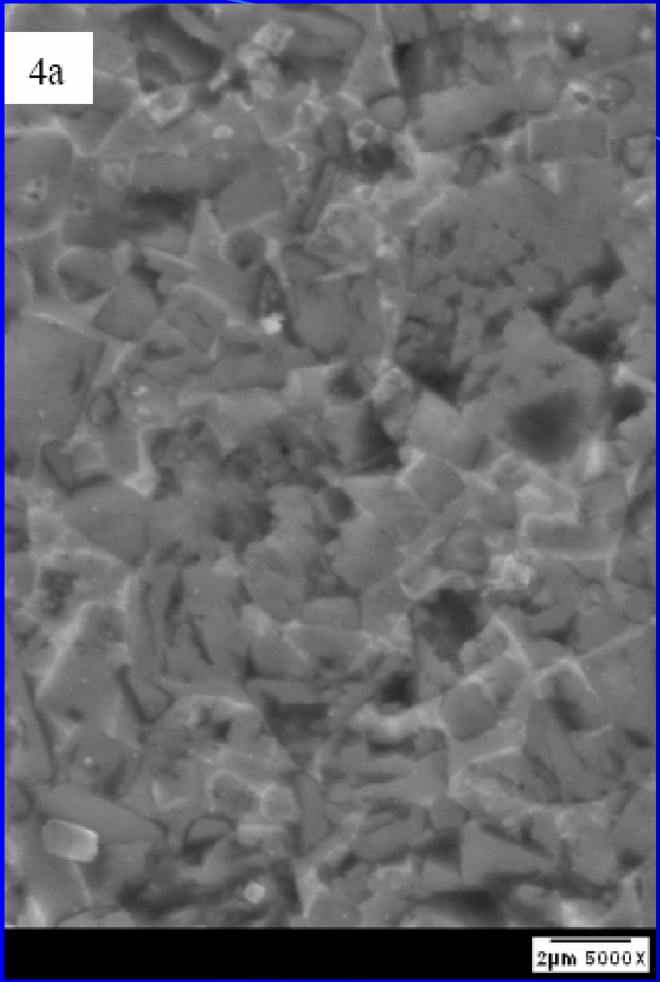


Figure 4a. TiC-25Ni_3Al internal (polished) microstructure after oxidation

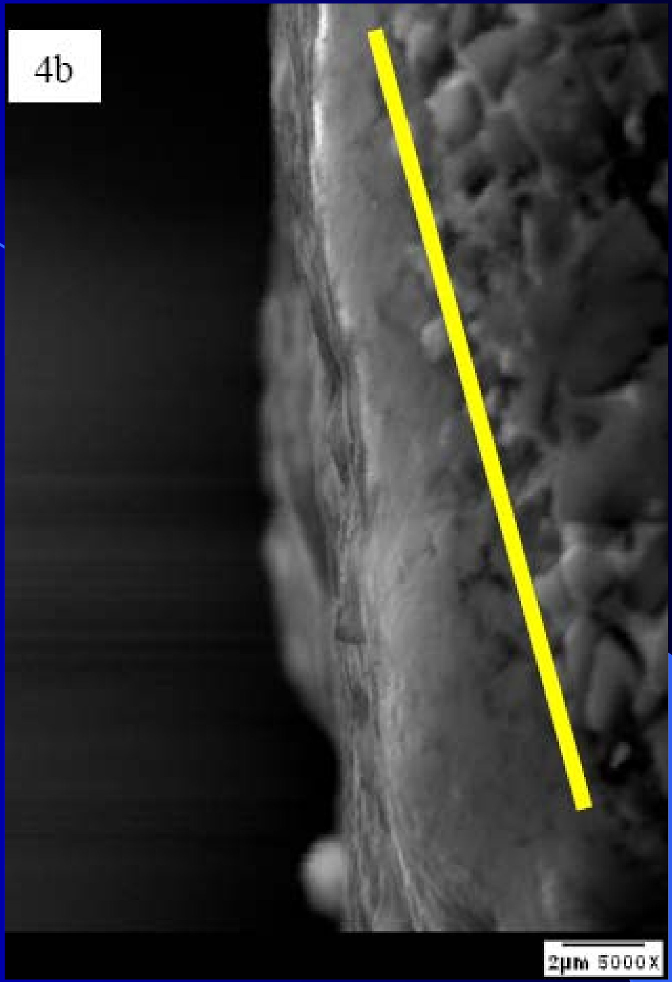


Figure 4b. TiC-25Ni_3Al oxidized and polished surfaces. Right of the line is the polished internal surface, left of line is oxidized surface. The oxide layer is approximately 1-2μm thick.

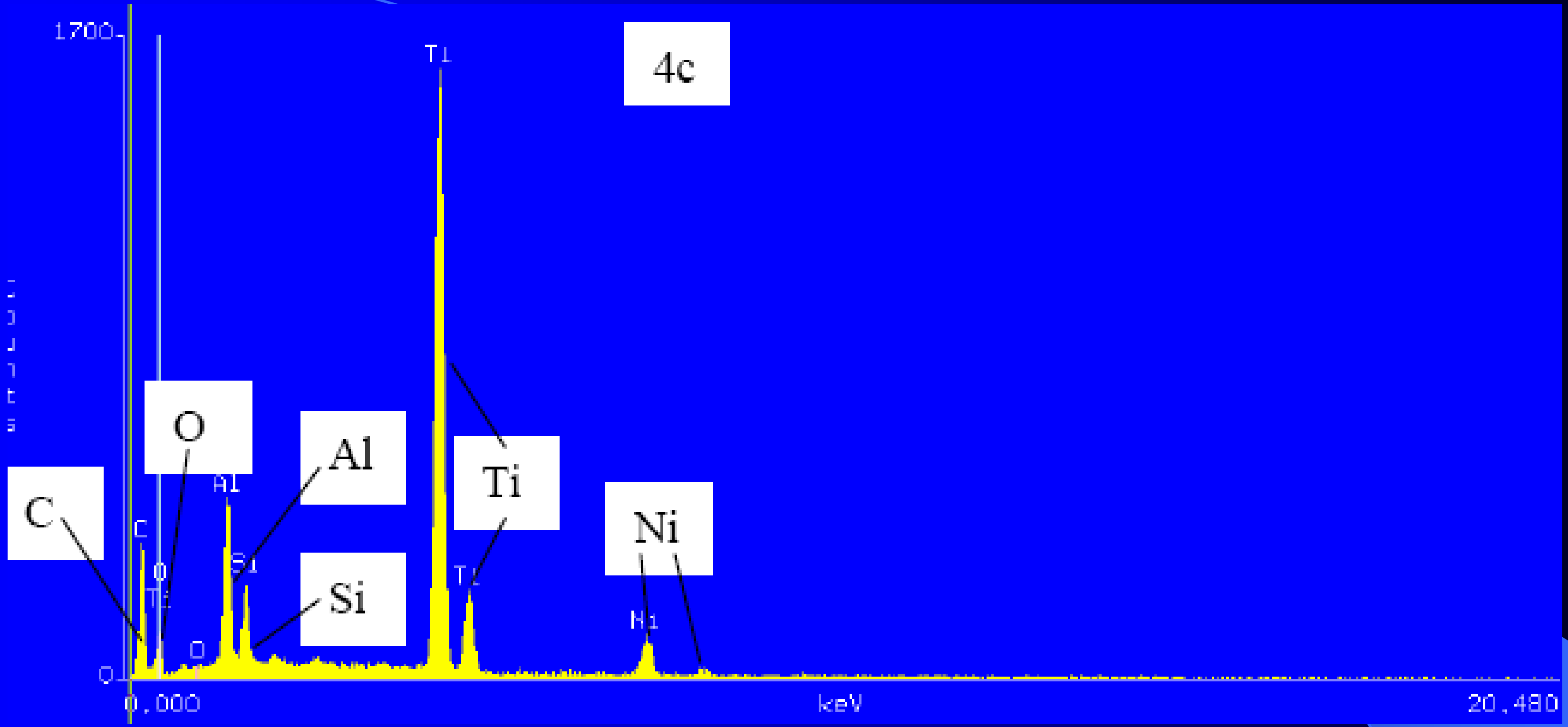


Figure 4c. EDX spectrum from TiC-25Ni_3Al sample surface after oxidation. Detected elements are similar to the 25Ni sample, save that the Al peak is of greater intensity, which correlates to the presence of Al in the intermetallic and not just from the polishing media. This indicates that for this sample, the oxide may be both Al and Ti oxides.

Conclusions

- $TiC-Ni-Ni_3Al$ materials are more suitable to SOFC interconnect applications than metallic alloys
- No Cr evaporation problems
- They have 100 % electronic conductivity in 10^{4-6} S/cm range in reducing conditions
- They have electrical conductivity of 20-30 S/cm in oxidizing condition due to formation of oxides of Ti or Ni
- CTE match with other cell components
- They are stable in reducing and oxidizing conditions at 800^{o}C