

# Absolute BE of Hydrocarbon C (1s) Peak from Clean Metals and Native Oxides

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C (1s) Binding Energies of "Hydrocarbons" on Native Oxides vs  
C (1s) Binding Energies of "Hydrocarbons" on Ion Etched Metals

<u>Element</u>	<u>C (1s) BE of Hydrocarbons on Native Oxides</u>	<u>C (1s) BE of Hydrocarbons on Ion Etched Metals</u>	<u>BE Diff.</u>	
Ag	285.5	284.7	+0.8	
Al	286.3	285.1	+1.2	
As	284.6	284.7	-0.1	
B	284.6	285.2	-0.6	
Be	285.6	284.4	+1.2	
Bi	285.4	284.8	+0.6	
Cd	286.0	285.0	+1.0	
Co	285.5	284.4	+1.1	
Cr	285.1	284.9	+0.2	
Cu	284.7	284.7	±0.0	
Fe	285.2	284.4	+0.8	
Ga	286.1	285.6	+0.5	
Ge	285.7	284.5	+1.2	
Hf	286.2	286.1	+0.1	
In	285.4	284.9	+0.5	
Ir	285.4	285.4	±0.0	
Mg	286.5 [FO]	284.4	+2.1	[FO]
Mn	284.8	286.3	-1.5	
Mo	284.8	285.2	-0.4	
Nb	285.1	284.9	+0.2	
Ni	285.4	284.9	+0.5	
Pb	285.6 [FO]	285.2	+0.4	[FO]
Pd	285.3	284.2	+1.1	
Re	284.5	285.0	-0.5	
Rh	284.6	284.0*	+0.6	
Sb	285.0 [FO]	284.4	+0.6	[FO]
Sc	285.9	286.8*	-0.9	
Se	284.3*	284.2	+0.1	
Si	285.7	284.9	+0.8	
Sn	285.2	284.8	+0.4	
Ta	284.8	284.6	+0.2	
Te	284.8	284.2	+0.6	
Tl	285.4 [FO]	285.2	+0.2	[FO]
V	285.1 [FO]	285.2	-0.1	[FO]
W	285.0	285.1	-0.1	
Y	286.7 [FO]	286.7	±0.0	[FO]
Zn	285.8	284.9	+0.9	
Zr	285.9	285.4	+0.5	

[FO] = Fresh Oxide made by scraping sample and exposing to air < 5minutes.

\* = The binding energies are uncertain due to overlapping signals.

## Notes:

1. Native oxide samples were analyzed As Received from the manufacturing company. All samples behaved as conductors and did not require the use of the charge neutralizer. When pure element was not observed, the sample was scraped with a knife and exposed to air for <5 minutes to produce a Fresh Oxide, which is probably different from the true native oxide but might still be useful as a guide until further studies are completed. The carbon on native oxides is due to long term storage for many months or years inside a closed bottle, inside a plastic bag, or inside an open container. Carbon on native oxides is due to gaseous organic chemicals captured from the air and also solid state organic chemicals transferred by physical contact with bottles, bags, spoons or other tools used to hold or move the samples from place to place. This type of carbon is frequently called adventitious carbon.
2. Ion etched samples were analyzed after the samples had been ion etched to remove all of the adventitious carbon and the native oxide, and kept in the vacuum of the X-Probe system (at  $5 \times 10^{-9}$  torr) for several hours (5-10 hours). The carbon on the ion etched samples is due only to gaseous and solid state organic chemicals that exist when that sample was inside the vacuum of the X-Probe system. Ion etched samples were never exposed to the lower vacuum of the load-lock (preparation) chamber or any other source of contamination. The organic chemicals on the surface of the sample were sprayed into the vacuum chamber by the ion etching process and most of them should have been captured by the cryopump. The organic chemicals on the surface which were not removed by ion etching can easily migrate across the surface of the sample and thus contaminate the ion etched clean surface. This migration is due to the dynamic (reactive) nature of the clean surface which has a free energy that is greater than the free energy of the fully equilibrated (static, non-reactive) nature of the surrounding native oxide with its layer of adventitious carbon. The free energy potential of the clean surface attracts the adventitious carbon because it is only loosely bound to surface of the native oxide.
3. Binding energies (BEs) of the carbide-like species, which were produced by the ion etching process, are not reported in this table. The BEs of carbide-like carbons produced by ion etching were found to range from 281.3 to 284.2 eV.
4. Water, which is also held by the surface, will also migrate across the surface, and react with the clean surface. Reactive gases, (carbon monoxide, methane, carbon dioxide, hydrogen, and oxygen) which always exist in vacuums can produce a variety of surface chemicals.
5. Even though the samples behaved as conductors, it is still possible that the charge neutralizer might have some effect on the BE values of the carbon on the native oxides. No attempt was made to study the effect of the charge neutralizer on the BEs of the native oxides.
6. No attempt was made to clean any of the native oxide samples.
7. All data are from single run experiments and as a result have a modest degree of accuracy. Statistical checks are needed to determine more accurate numbers. Based on some simple checks, the numbers might have errors as large as  $\pm 0.3$  eV.