Application News

No.P99

Electron Probe Microanalyzer

Analysis of Surface Hardening Treatments Using the EPMA-8050G

Introduction

The steel used in familiar, everyday mechanical components (such as gears, bearings, and screws) must be wear-resistant and tough, so its surfaces are hardened, and internally, surface hardening treatments are applied to maintain toughness. There are several types of steel surface hardening treatments in which the surface is hardened by quenching after heating. In one type, the surface components are modified and hardened, as in carburized quenching and nitriding. In flame hardening and induction quenching, hardened is applied only to the surface by quenching.
Here, we introduce a sample analysis of carbonitrided steel (SCM) and gas carburized steel (gears) using the EPMA-8050G (FE-EPMA).

Carbonitriding

Carbonitriding is a thermochemical treatment used to enrich the surface layer of steel with carbon and nitrogen that are normally dissolved in austenite. Since the surface density and surface layer thickness are varied depending on the objective, it is important to investigate the surface density and the treatment depth.
In the C and N mapping in Fig. 1, the fine density gradient from the surface towards the interior is obtained as a smooth color gradation. The density gradient can be also confirmed as a line profile through a linear analysis, in which the vertical (Y) direction of this mapping data is averaged.

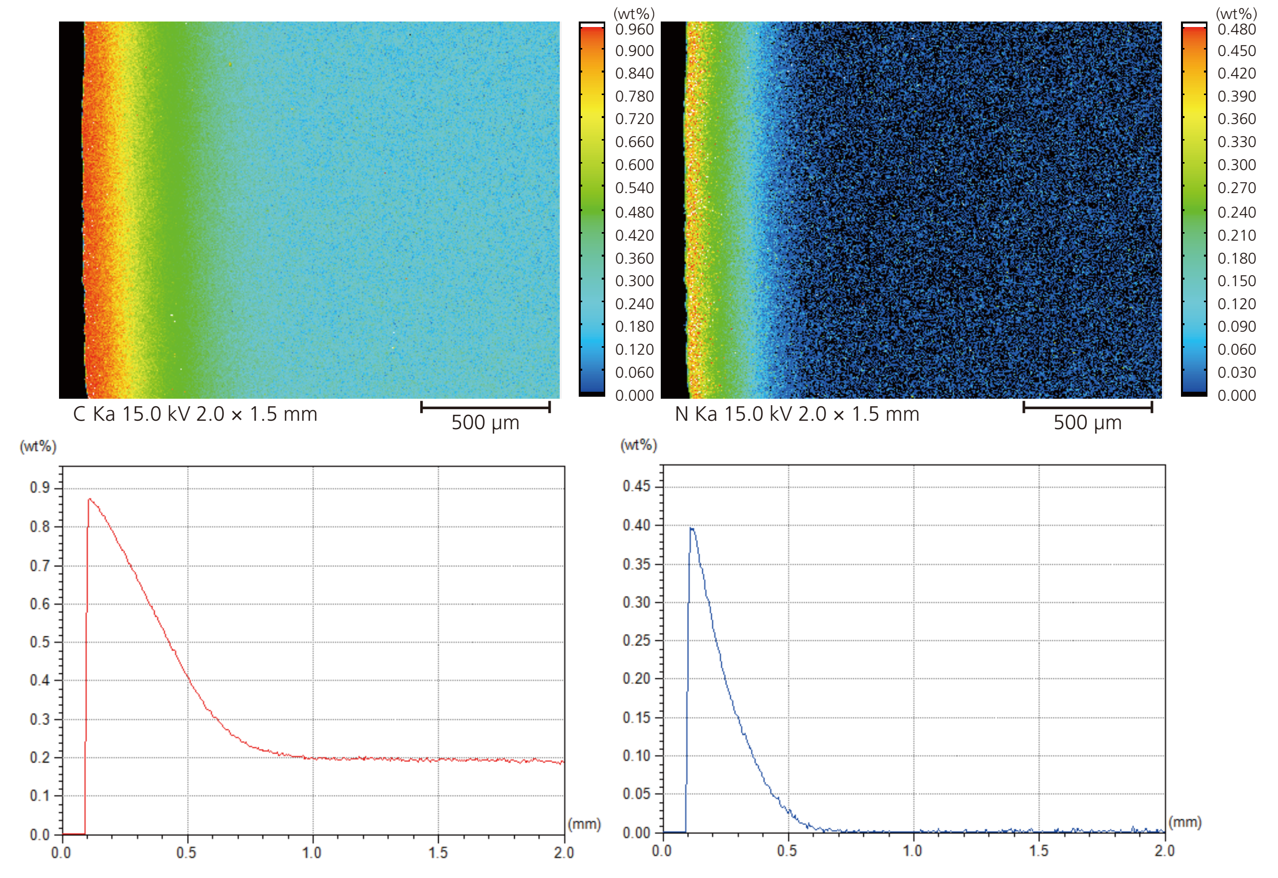

Fig. 1 C and N Elemental Mapping and Linear Profile

Carburized Abnormal Layer

When gas carburization is applied to a steel surface, a carburized abnormal layer (approximately 10 µm thick), is formed on the outermost surface layer due to grain boundary oxidation (Si, Cr, and Mn). This abnormal layer is a softened structure in which hardenability is reduced due to a depletion of elements that improve hardenability, and so it tends to become a starting point for fatigue fractures. In Fig. 2, it is evident that Si and Mn are depleted in the carburized abnormal layer, and that oxidized Si and Mn have precipitated at the grain boundary.

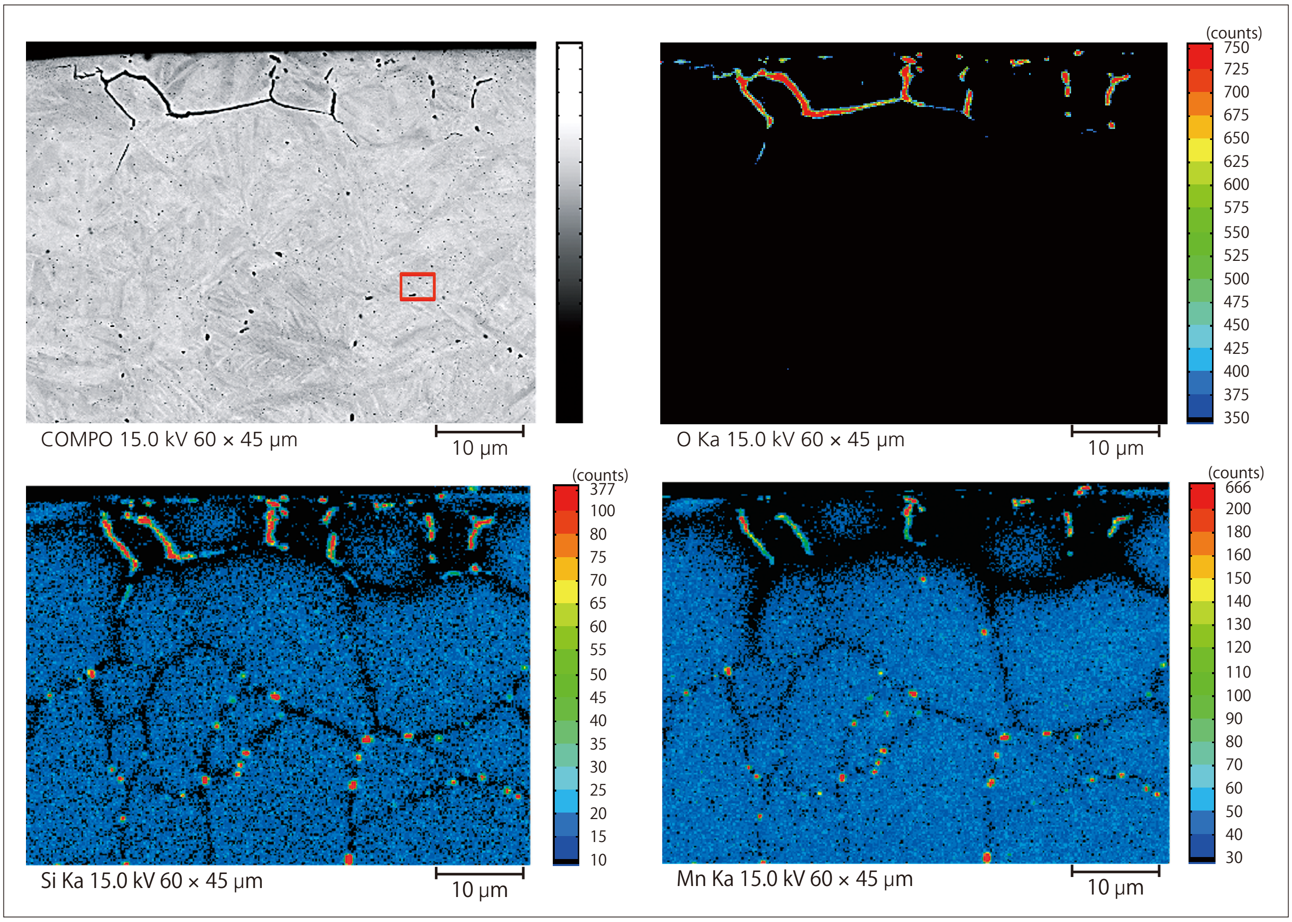

Fig. 2 Elemental Mapping of the Carburized Abnormal Layer

Grain Boundary Precipitation

In Figs. 2 and 3, a depletion layer (about 0.5 µm), in which the solid solution density of Si and Mn is low in comparison to the intragranular matrix, is visible in proximity to the grain boundary. It is evident that coarse and high-density Si and Mn grains (with lengths of about 1.0 µm) precipitate within this depletion layer (grain boundary precipitation). In Fig. 3 (the region in the red rectangle in Fig. 2), the existence of fine Si and Mn inclusions of approximately 50 nm, generated by the cooling process, can be confirmed in the intragranular matrix.

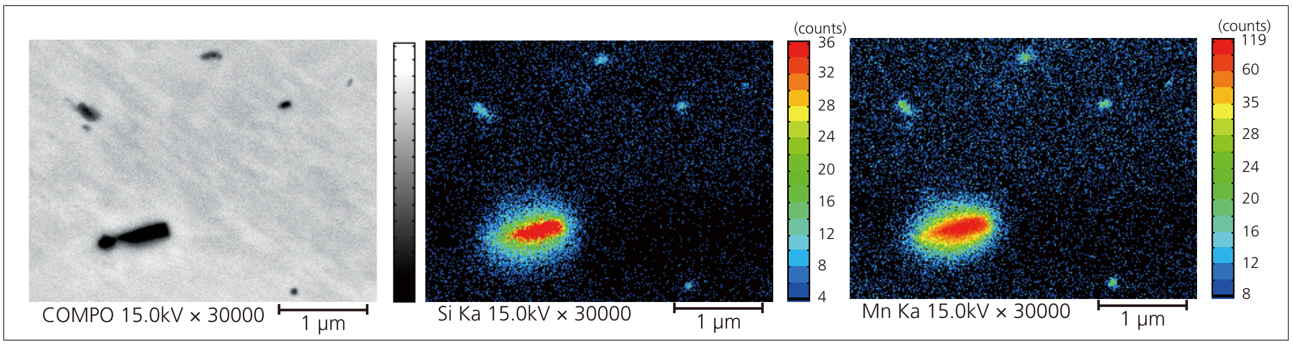

Fig. 3 Elemental Mapping of Metallic Inclusions

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