Decarburization of 0.21C-1.3Mn-0.2Si steel at various heating temperatures

Corporate R&D Labs., Sumitomo Metal Industries Ltd.
K. Hayashi, T. Saitou and T. Nishibata
Tokyo Institute of Technology
M. Kajihara

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  Hot stamping, Decarburization
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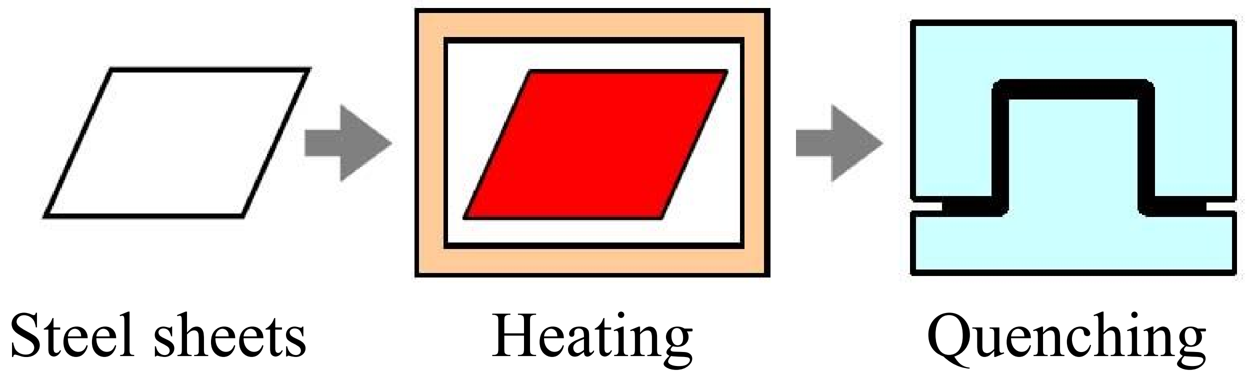
  Optimum heat treatment conditions
  Rate-controlled process

Background

- Hot stamping method

Automotive parts with fully martensite structure



- Heating conditions

Austenitic temperature (~1173K) : High temperature

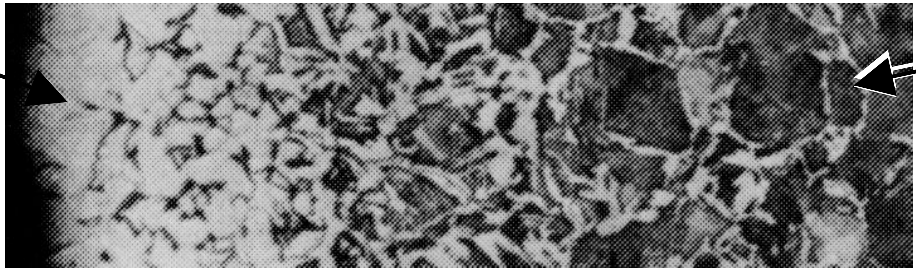
Ambient or gas atmosphere : Oxidation atmosphere

Decarburization conditions

Purpose

Microstructure of carbon steel due to decarburization

Ferrite



Pearlite

High temperature oxidation of metals, Cambridge Univ. Press, p152

Effects of decarburization on mechanical properties

Advantage	Bendability, Impact strength
Disadvantage	Tensile strength, Fatigue strength

Purpose : Examine the effect of annealing temperatures on decarburization using a Fe-0.21C-1.3Mn-0.2Si steel

Experimental Procedure

- Cold rolled sheet steel

  Thickness: 2.4mm

  Chemical composition and A_{e3} of steel in mass%:

C	Si	Mn	P	S	A_{e3}
0.21	0.2	1.3	0.01	0.003	1078K

- Heating conditions

  Rapid heating

  Water quenching

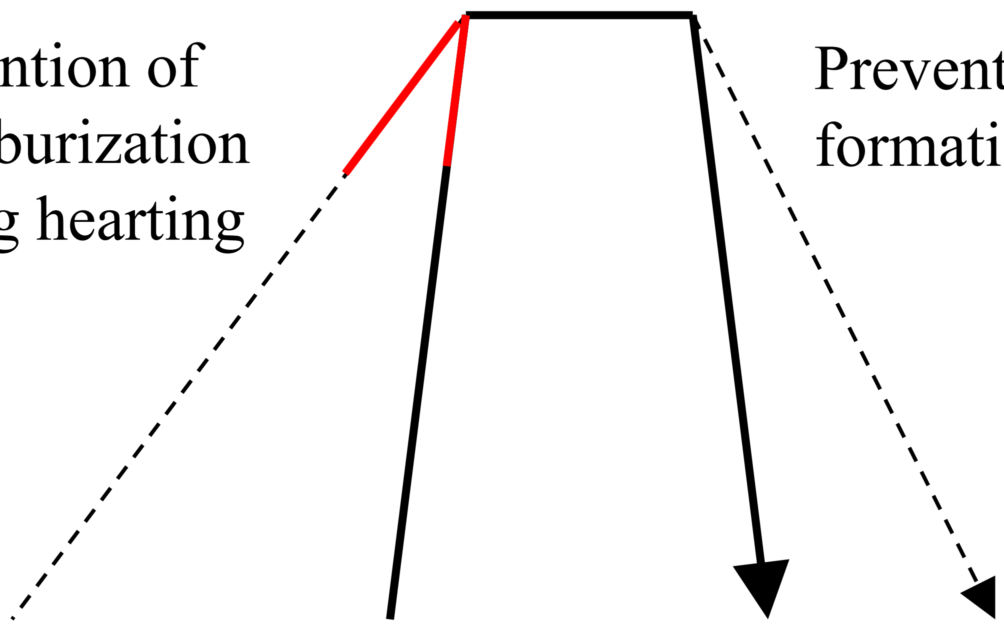
- Microstructure analysis

  Laser scanning microscope (LSM)

  Electron probe microanalysis (EPMA)

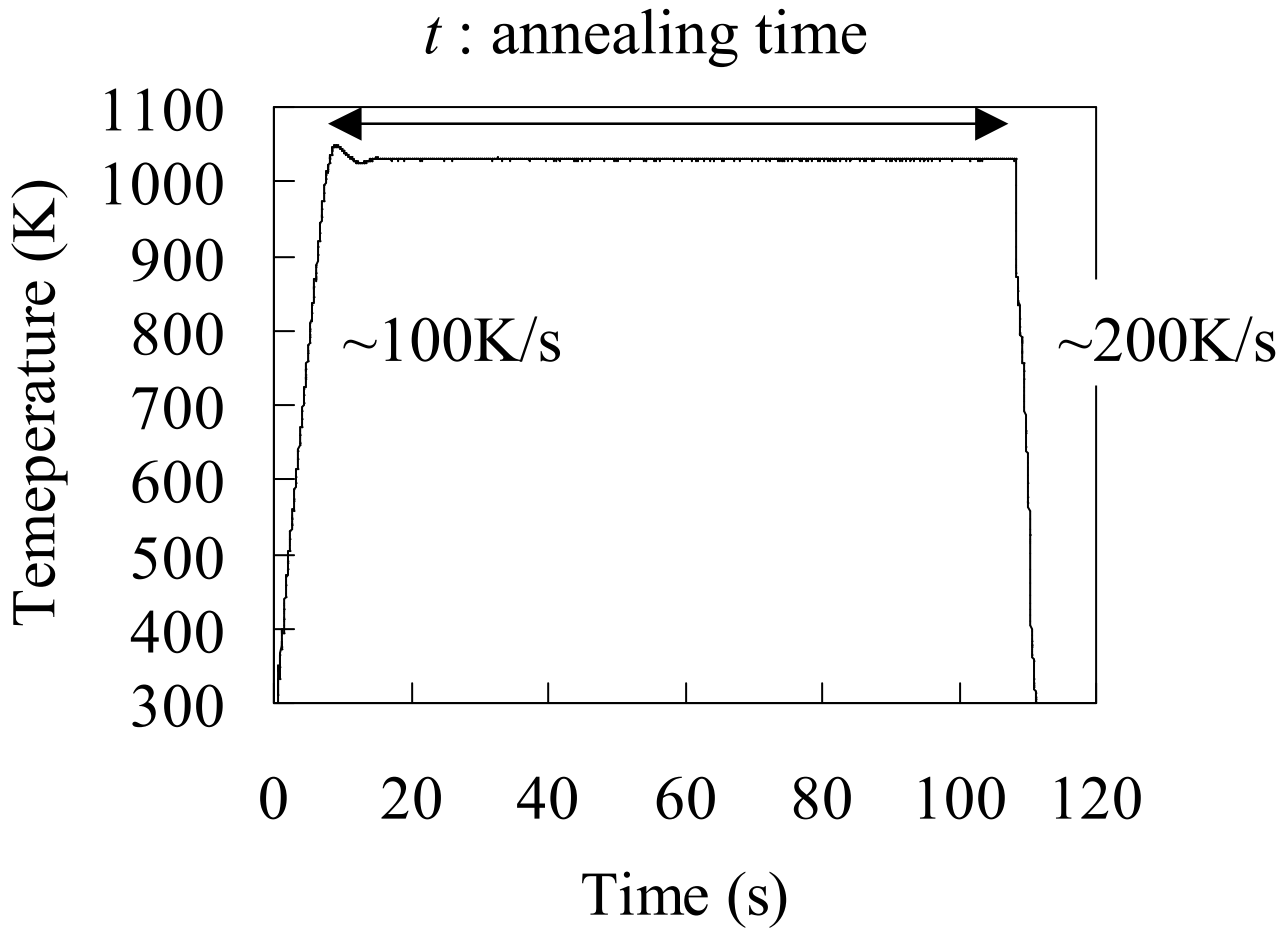
Heating conditions

Rapid heating & Water quenching method



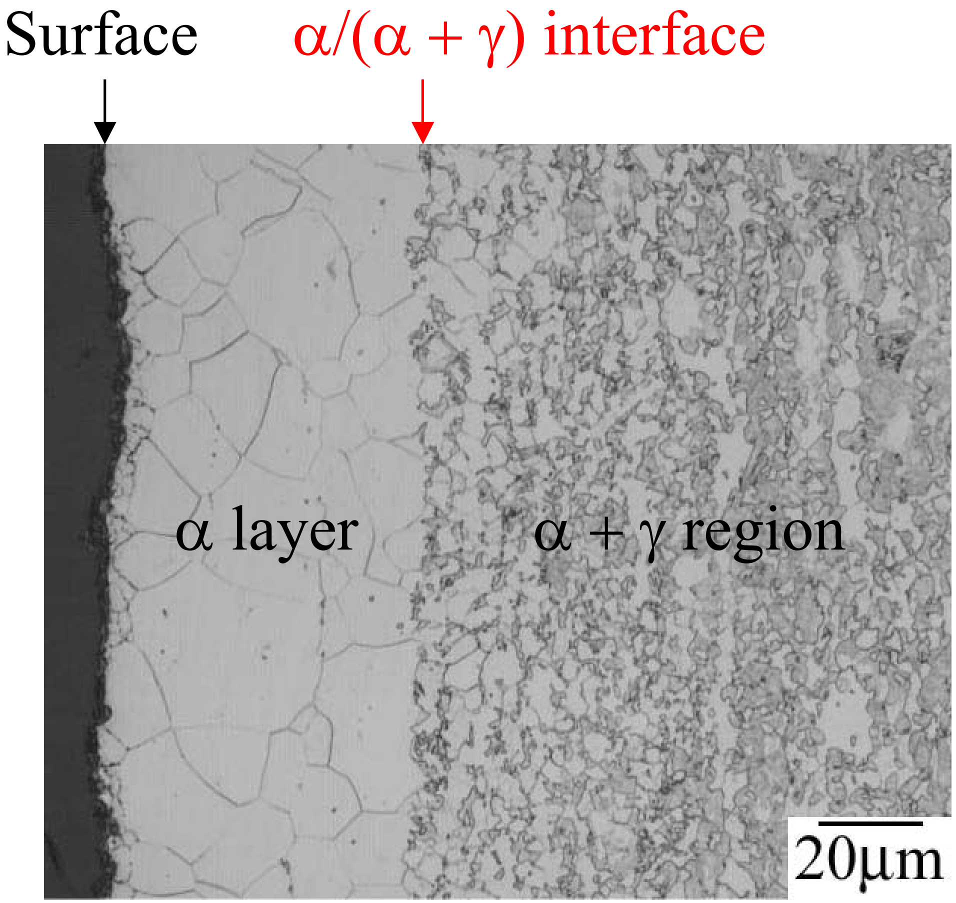
Temperature during Heat treatment

<u>Annealed at 1033K for 100s</u>

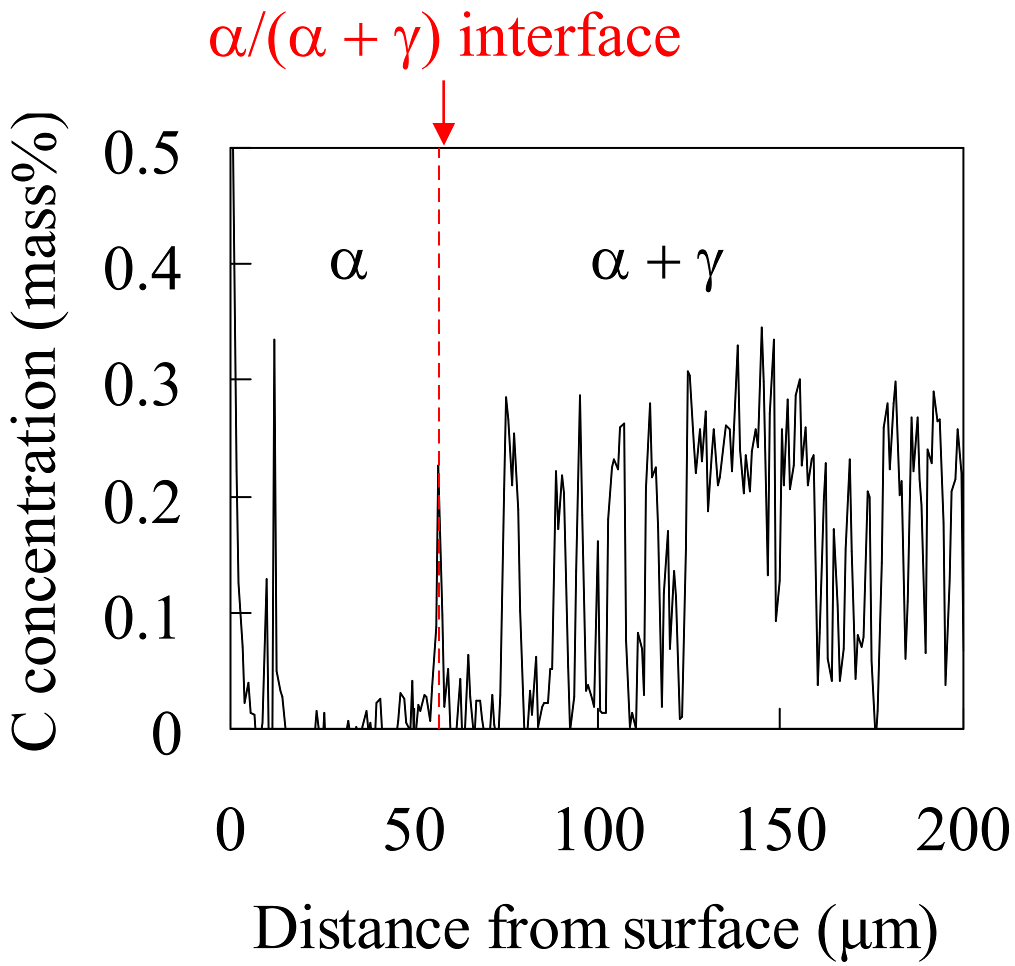


Microstructure

Annealed at 1033K for 1600s

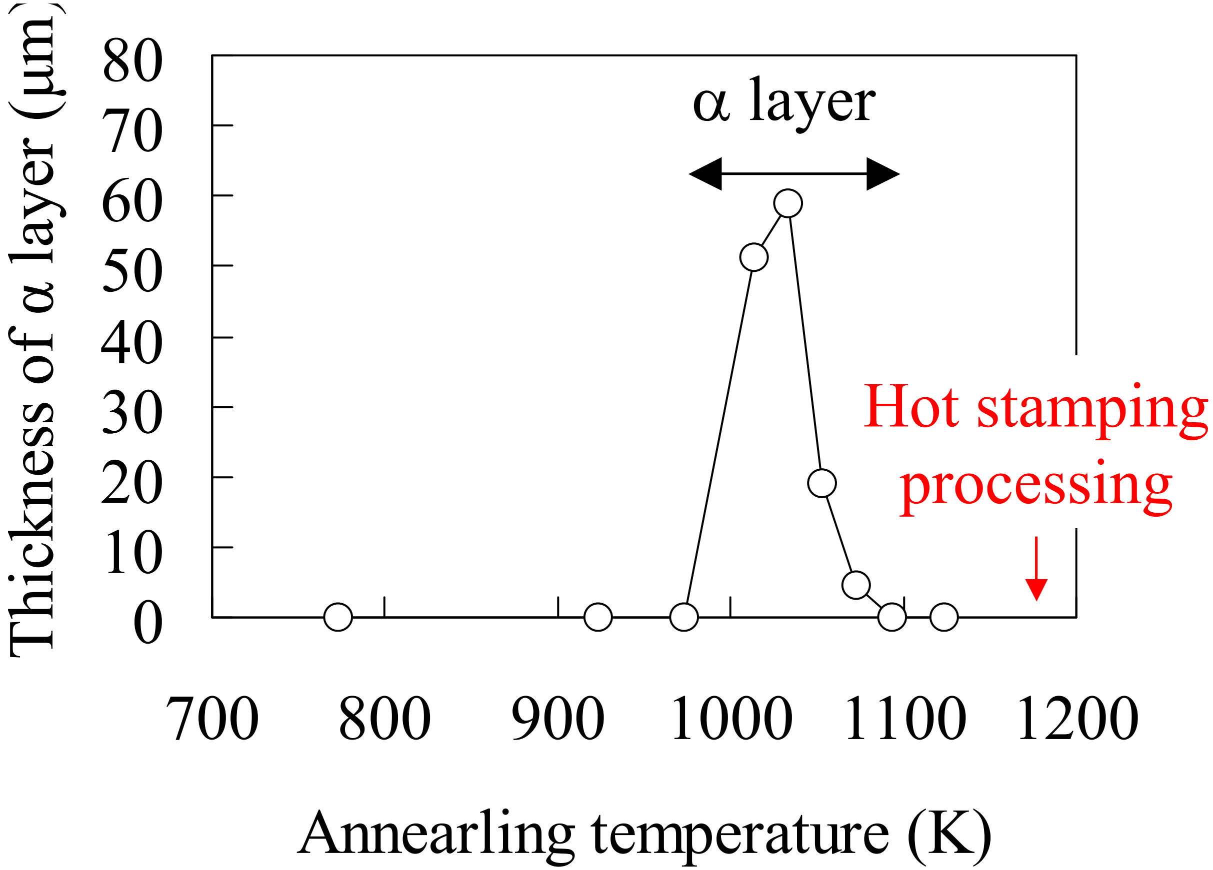


C concentration profile



Thickness of α layer vs. temperature

Annealed for 1600s



Summary of microstructure observation

Fe–0.21C–1.3Mn-0.2Si, T = 773–1173K, t = 1600s

- Formation of the ferrite layer at the surface due to decarburization

  $T = 1013\text{–}1073\text{K}$

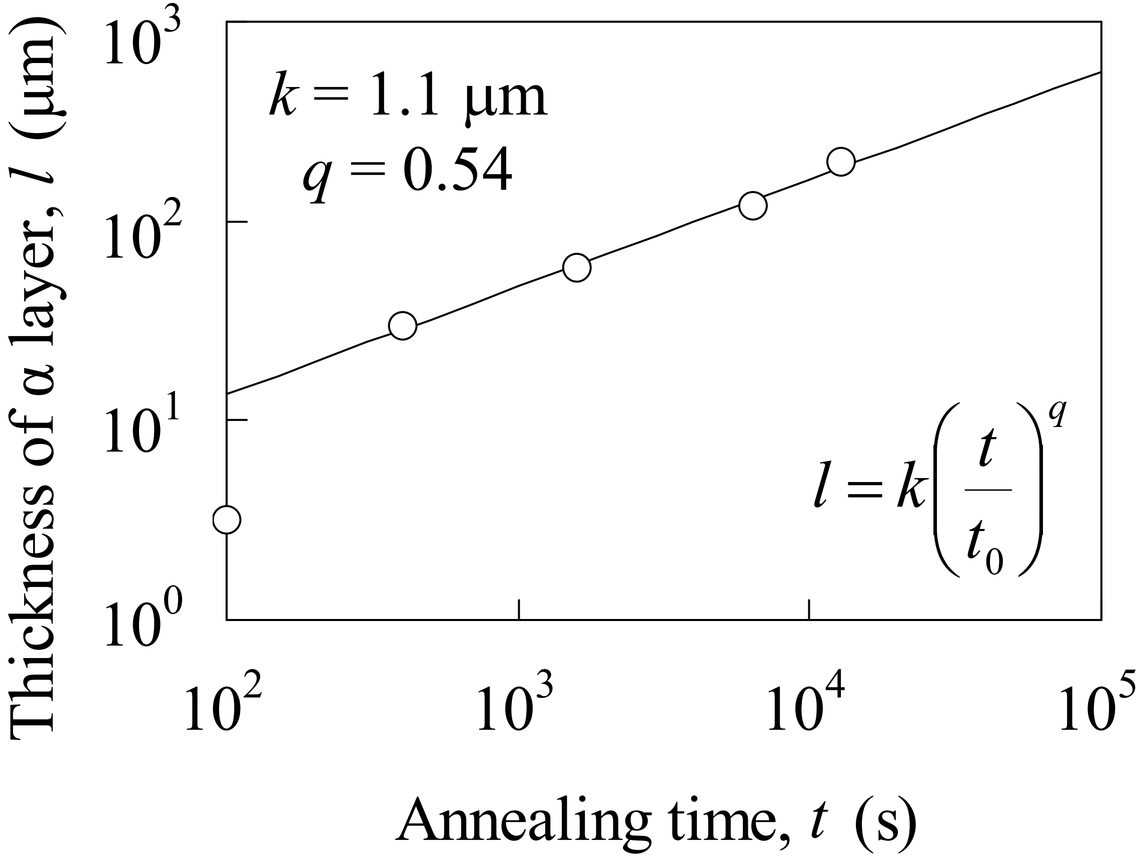
- The peak temperature

  $T_p = 1033\text{K}.$

- Heating at $T > 1093\text{K}$

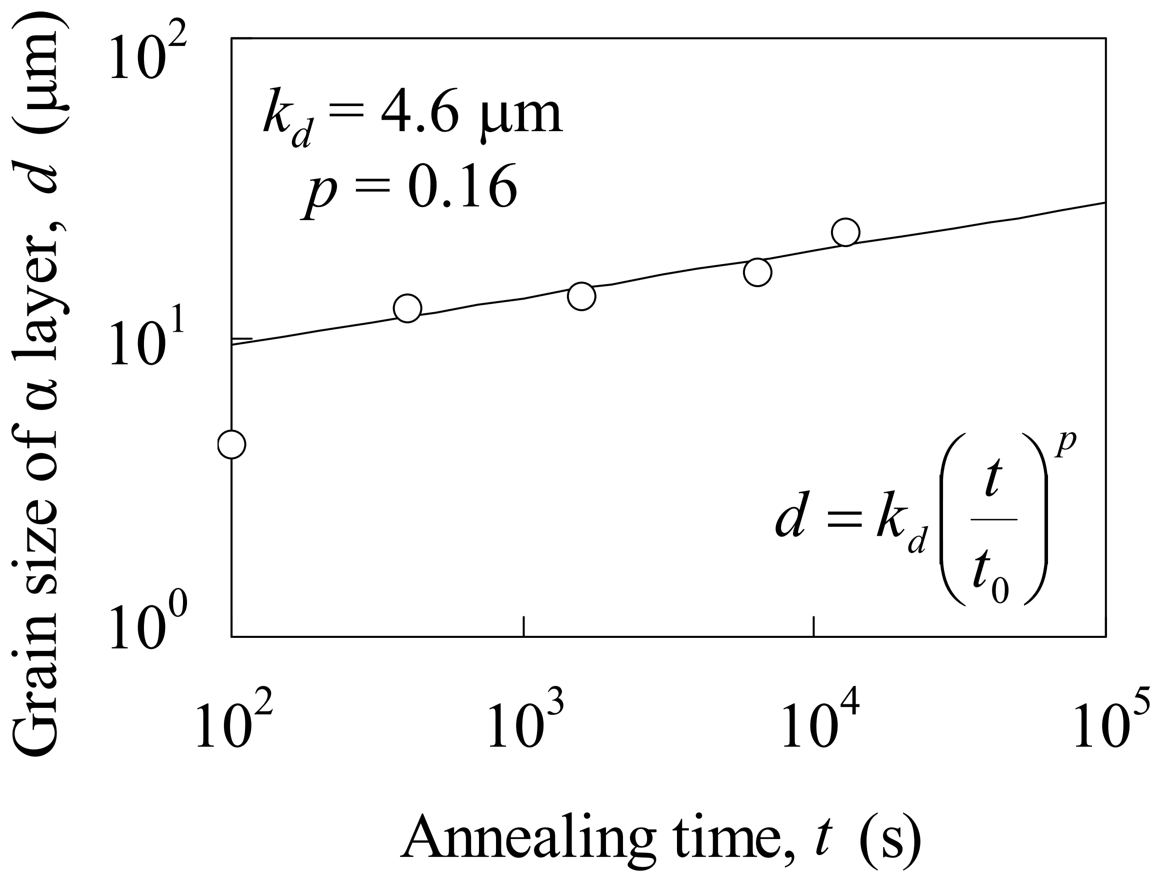
  Prevention of the ferrite formation

Growth behavior of α layer



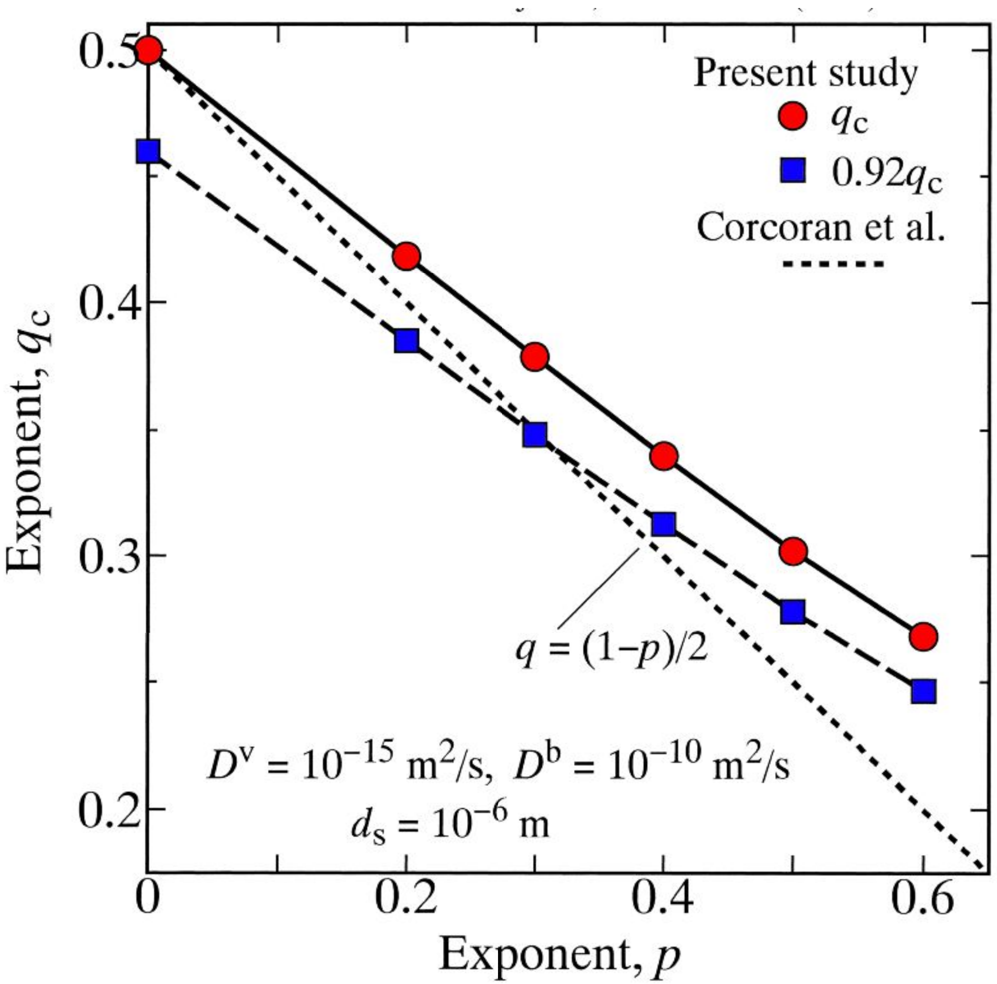
t_0 : unin time (1s), k : proportionality coefficient, q : exponent

Grain growth in α layer



t_0 : unin time (1s), k_d : proportionality coefficient, p : exponent

Relationship between *q* and *p*



A. Furuto & M. Kajihara,
Mater. Trans., (2008)

Boundary diffusion
with grain growth

$$q_{cal} = \frac{1 - p_{\exp}}{2} = 0.42$$

Y. L. Corcoran et al.,
J. Electron. Mater., (1990)

Conclusion

Fe-0.21C-1.3Mn-0.2Si, T = 773~1173K, t = 100~12800s

- Formation of the ferrite layer at the surface

  $T = 1013–1073\text{K}$, $T_P = 1033\text{K}$ for 1600s

- Heating at $T > 1093\text{K}$

  Prevention of the ferrite formation

- Growth behavior of the ferrite layer

  l vs. t, Parabolic relation ($q \sim 0.5$)

- Rate-controlling process for the ferrite layer during annealing at 1033K

  Volume diffusion