Effect of Ferromagnetic Substrates on ac Losses in YBCO Coated Conductors

P. M. Grant, (Electric Power Research Institute)

N28.002: 8:12 14 March 2001

Coated Conductors
Generation II Wire

Copper oxide plane

● Copper ● Oxygen ● Oxygen vacancy

Thick YBCO film

I

H

Textured layer

Polycrystalline alloy substrate

EPRI

Effect of Ferromagnetic Substrates on ac Losses
in YBCO Coated Conductor Tape

Paul M. Grant
N28.002: 8:12 14 March 2001

Cross Section

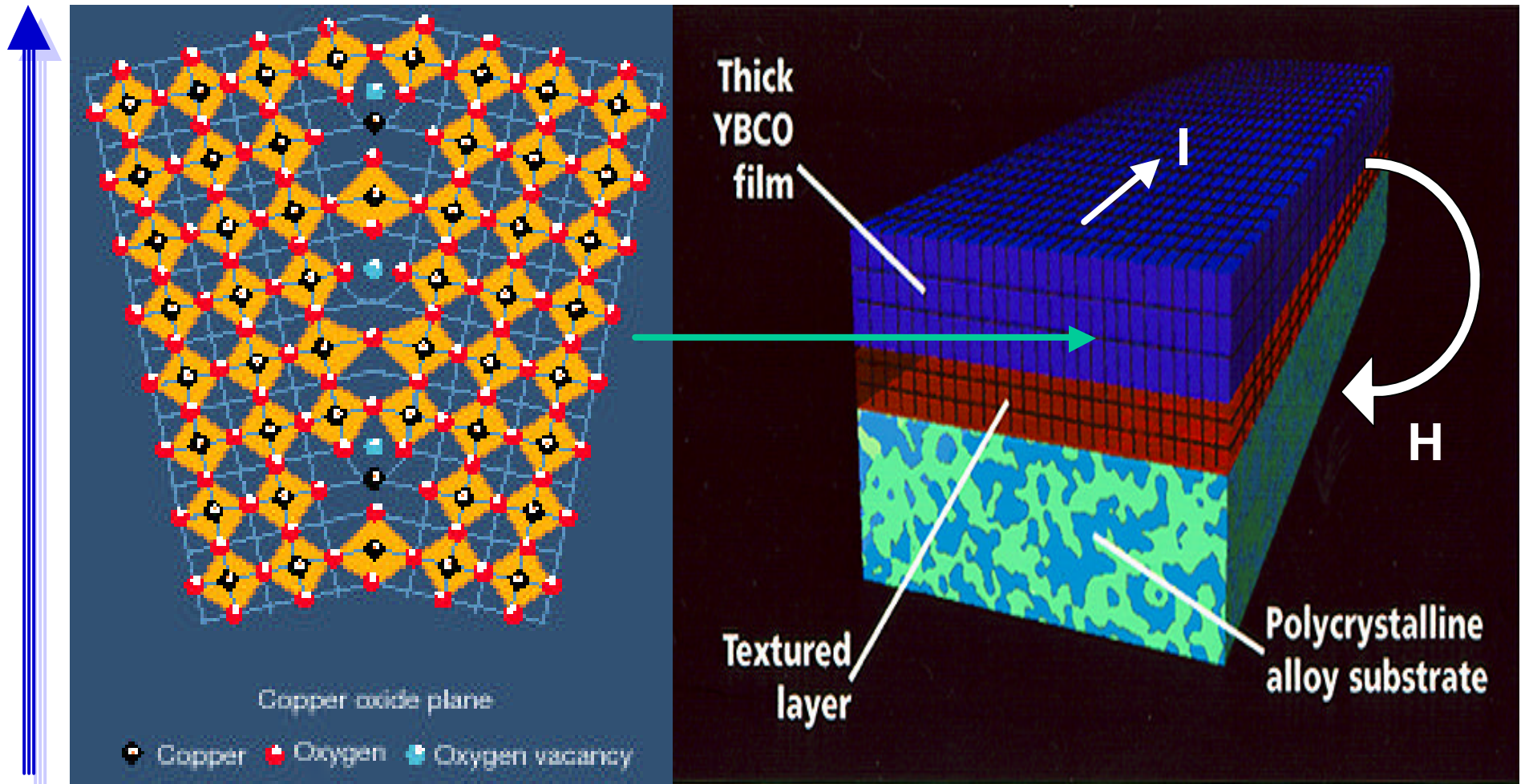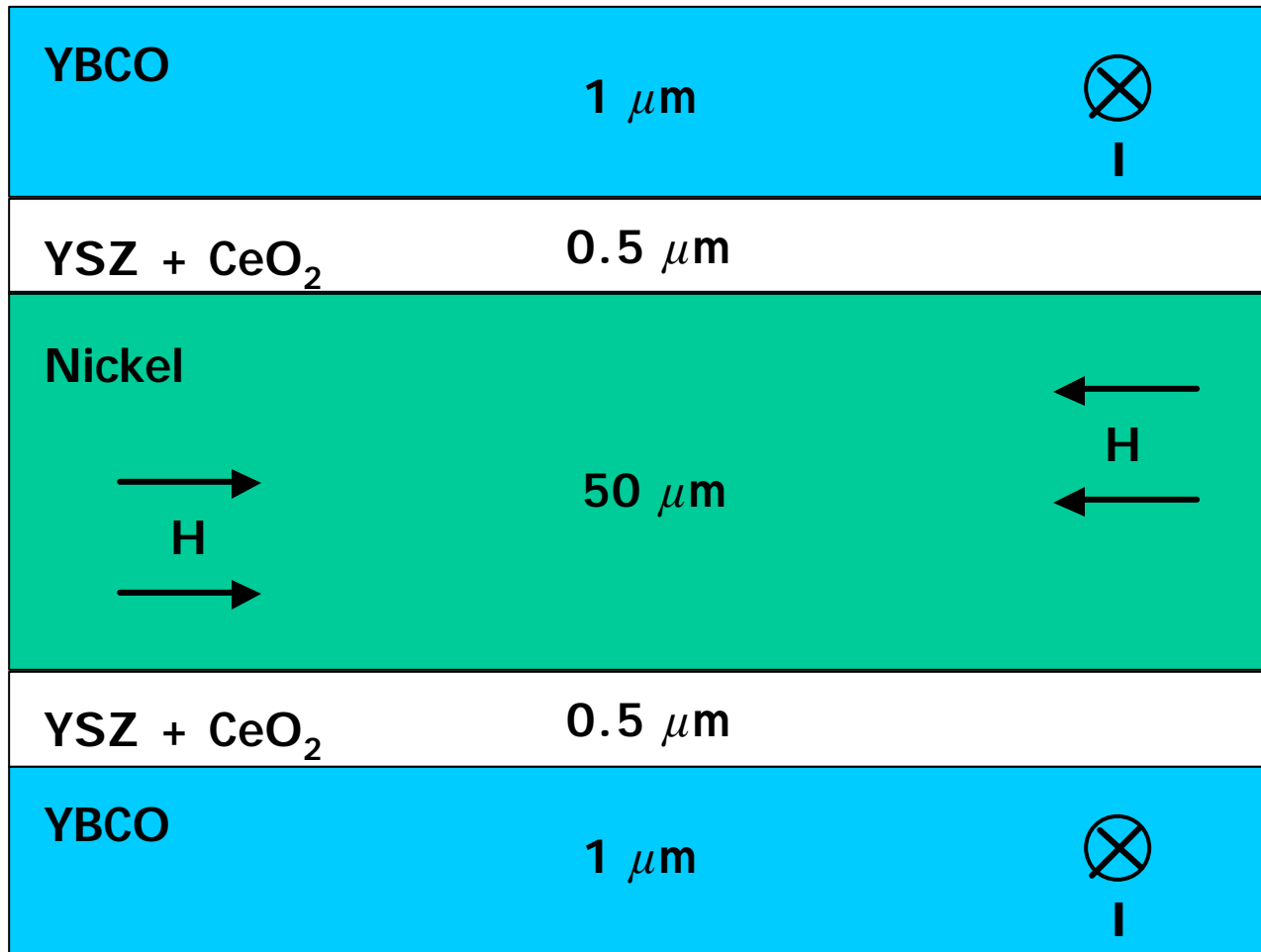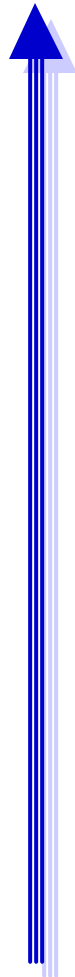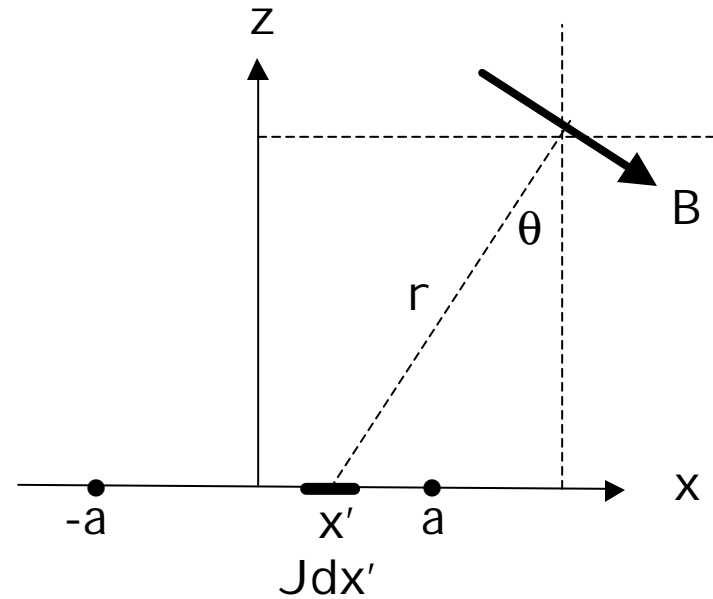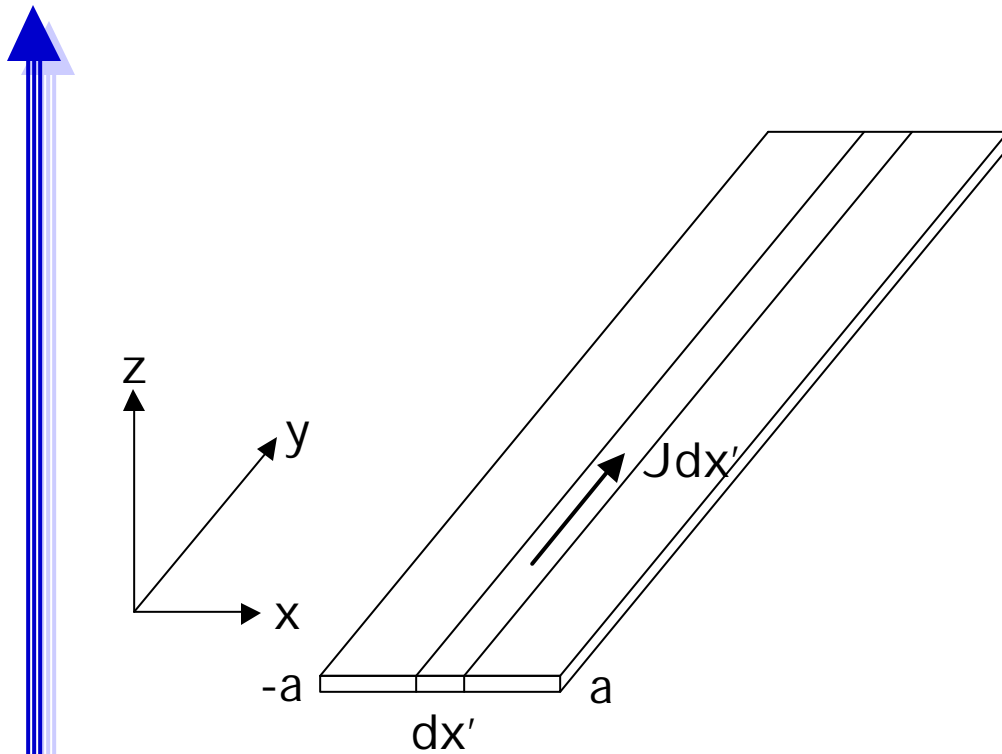|	
YBCO	1 μm $\quad \otimes$ I
YSZ + CeO$_2$	0.5 μm
Nickel	50 μm $\quad$ H
YSZ + CeO$_2$	0.5 μm
YBCO	1 μm $\quad \otimes$ I

Biot-Savart

$$dB_x(x,z) = \frac{\mu_0}{2\pi} Jz \frac{dx'}{(x-x')^2 + z^2}$$

$$- dB_z(x,z) = \frac{\mu_0}{2\pi} J \frac{(x-x')\ dx'}{(x-x')^2 + z^2}$$

EPRI

Effect of Ferromagnetic Substrates on ac Losses
in YBCO Coated Conductor Tape

Field Equations

$$B_x(x,z) = \frac{\mu_0}{2\pi} J \frac{1}{z} \left[\tan^{-1} \left(\frac{x+a}{z} \right) - \tan^{-1} \left(\frac{x-a}{z} \right) \right]$$

$$B_z(x,z) = \frac{\mu_0}{2\pi} J \frac{1}{2} \ln \left[\frac{(x-a)^2 + z^2}{(x+a)^2 + z^2} \right]$$

Field Distribution

Substate Field Surface

a = 2 mm
J = 25 A/mm

EPRI

Effect of Ferromagnetic Substrates on ac Losses
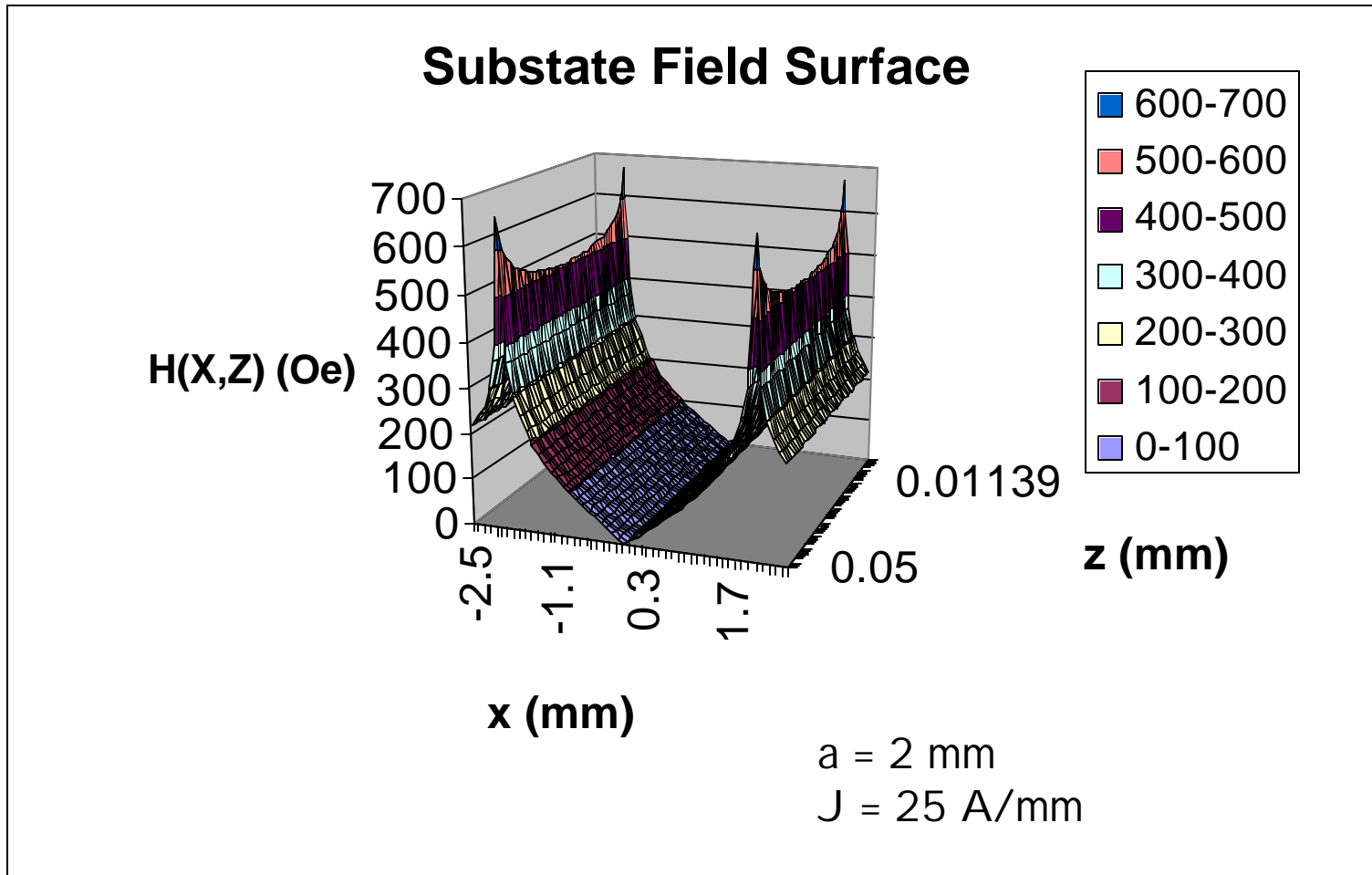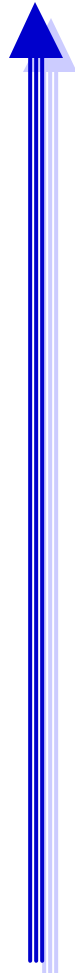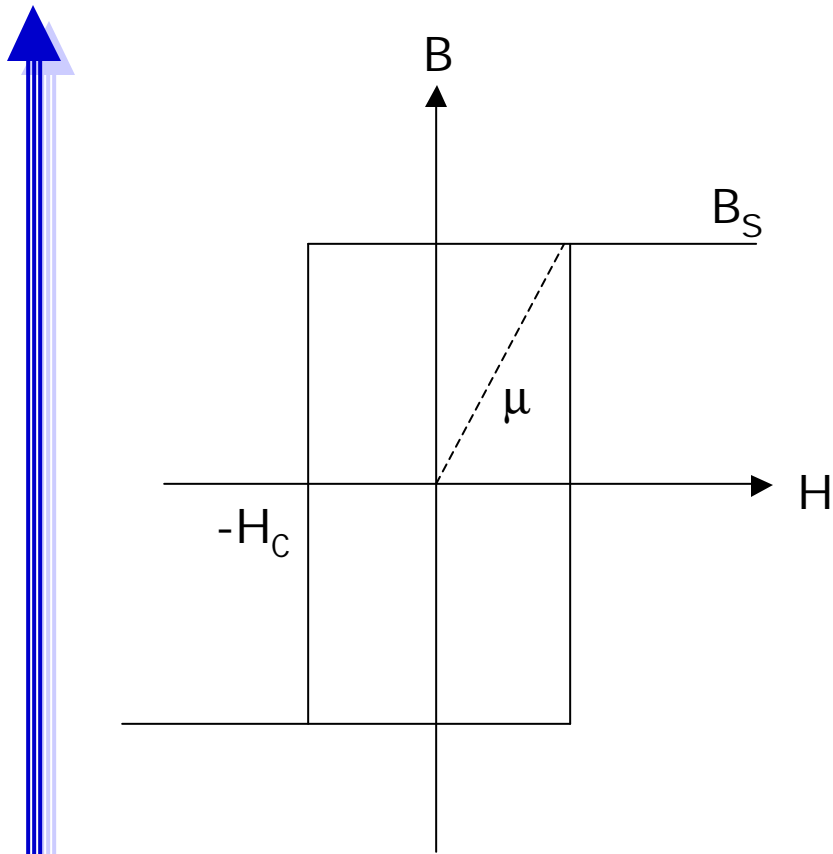in YBCO Coated Conductor Tape

Paul M. Grant
N28.002: 8:12 14 March 2001

Hysteresis

$$H > H_C \; ; \;\; P = \frac{2f}{\mu_0} \, H_C \, B_S$$

$$H < H_C \; ; \;\; P = \frac{2\mu f}{\mu_0} \, H^2$$

Loss

H_C = 80 Oe

B_S = 6000 Gauss

μ = 75

P = 0.14 W/m

Measured ac Losses
Y-123 cc on Hastalloy (non-magnetic)
= 0.48 W/m (Ciszek, et al.)

EPRI

Effect of Ferromagnetic Substrates on ac Losses
in YBCO Coated Conductor Tape

Paul M. Grant
N28.002: 8:12 14 March 2001

Conclusions

"Spending a nickel
does cost you something
even these days"

EPRI

Effect of Ferromagnetic Substrates on ac Losses
in YBCO Coated Conductor Tape