Magnetostriction of Polycrystalline TbDy at Cryogenic Temperatures

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Outline

- Introduction
- Recent Measurements at 77 K
- Thermal Expansion Measurements
- Future Work
- Conclusions

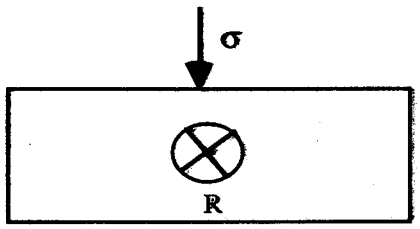
Materials:

$Tb_{0.60}Dy_{0.40}$
-Estimated anisotropy minima at 77K

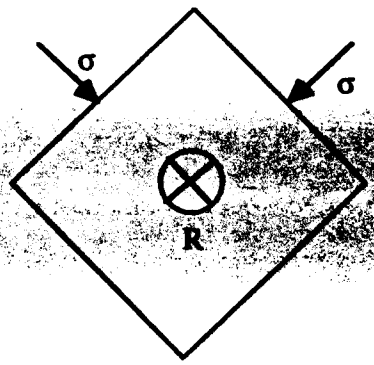
$Tb_{0.76}Dy_{0.24}$
-Estimated anisotropy minima at 4K

Rolling:

Plane Rolled:

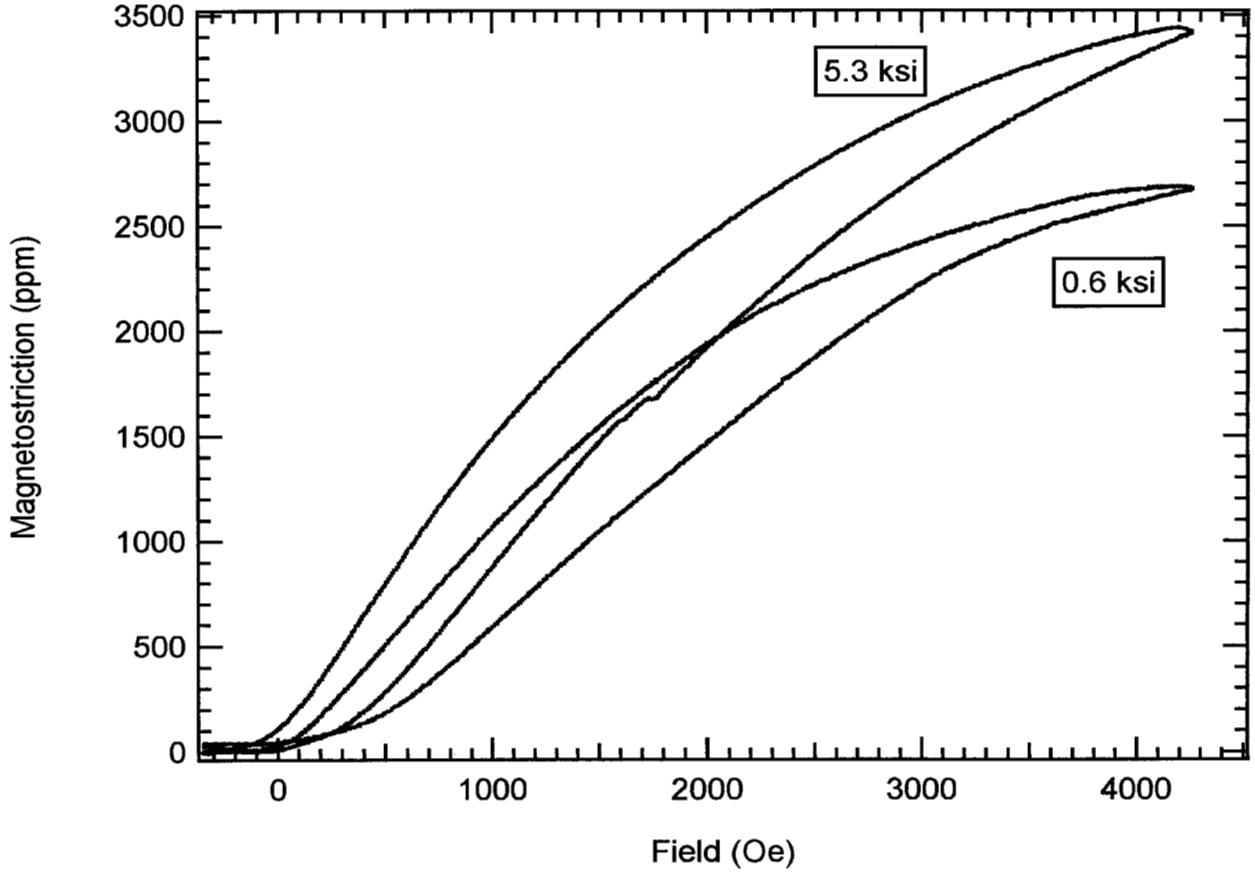


Form Rolled:



Plane rolled

$Tb_{0.6}Dy_{0.4}$ specimen was (plane rolled 55 %, 350°C 1.5 hrs) x2



$Tb_{0.6}Dy_{0.4}$ specimen (plane rolled 55 %, 350°C 1.5 hrs) => 3000ppm at 6 ksi, 4.5 Oe

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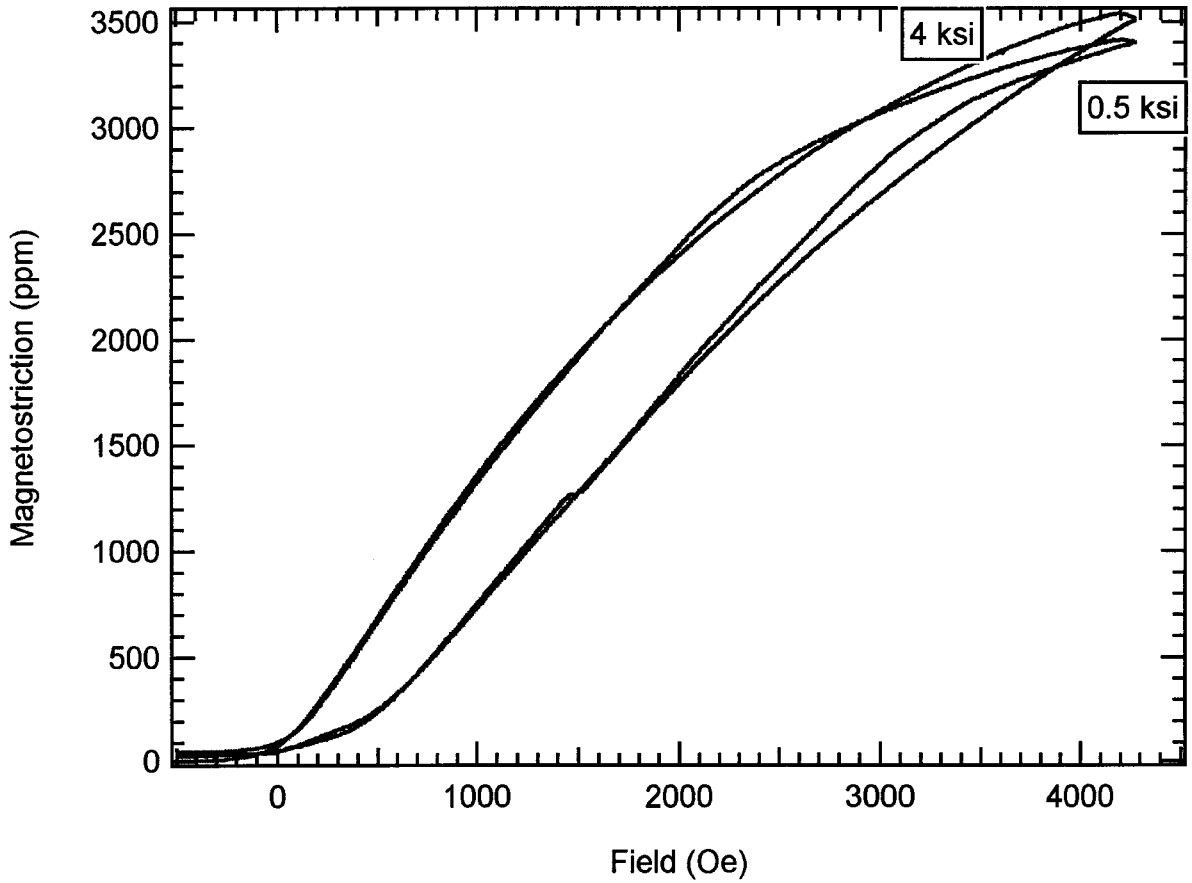
Plane rolled

$Tb_{0.6}Dy_{0.4}$ specimen was (plane rolled 25 %, 350°C 3 hrs) x4



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Texture Determination by Measurement of Thermal Expansion

- Anisotropic thermal expansions reported for single crystal Tb/Dy at 400°C[1]
  - Tb: 9.1 x 10^{-6}/ K (a-axis), 17.9 x 10^{-6}/ K (c-axis)
  - Dy: 4.7 x 10^{-6}/ K (a-axis), 20.3 x 10^{-6}/ K (c-axis)

- Measured for single crystal (30°C to 300°C)
  - Tb: 3.8 x 10^{-6}/ K (a-axis), 14.5 x 10^{-6}/ K (c-axis)
  - Dy: 3.4 x 10^{-6}/ K (a-axis), 15.2 x 10^{-6}/ K (c-axis)
  - $Tb_{0.6}Dy_{0.4}$: 3.1 x 10^{-6}/ K (a-axis), 15.2 x 10^{-6}/ K (c-axis)
  - Plane-rolled $Tb_{0.6}Dy_{0.4}$: 4.0 x 10^{-6}/ K (rod-axis, ideally would be a-axis value)
  - Form-rolled $Tb_{0.6}Dy_{0.4}$: 4.5 x 10^{-6}/ K (rod-axis, ideally would be a-axis value)

- Thermal expansion measurements offer a relative measure of texture useful for comparing specimens.

[1]F. H. Spedding, J. J. Hanak, A. H. Daane, J. Less-Common Metals, **3**, 110, (1961).

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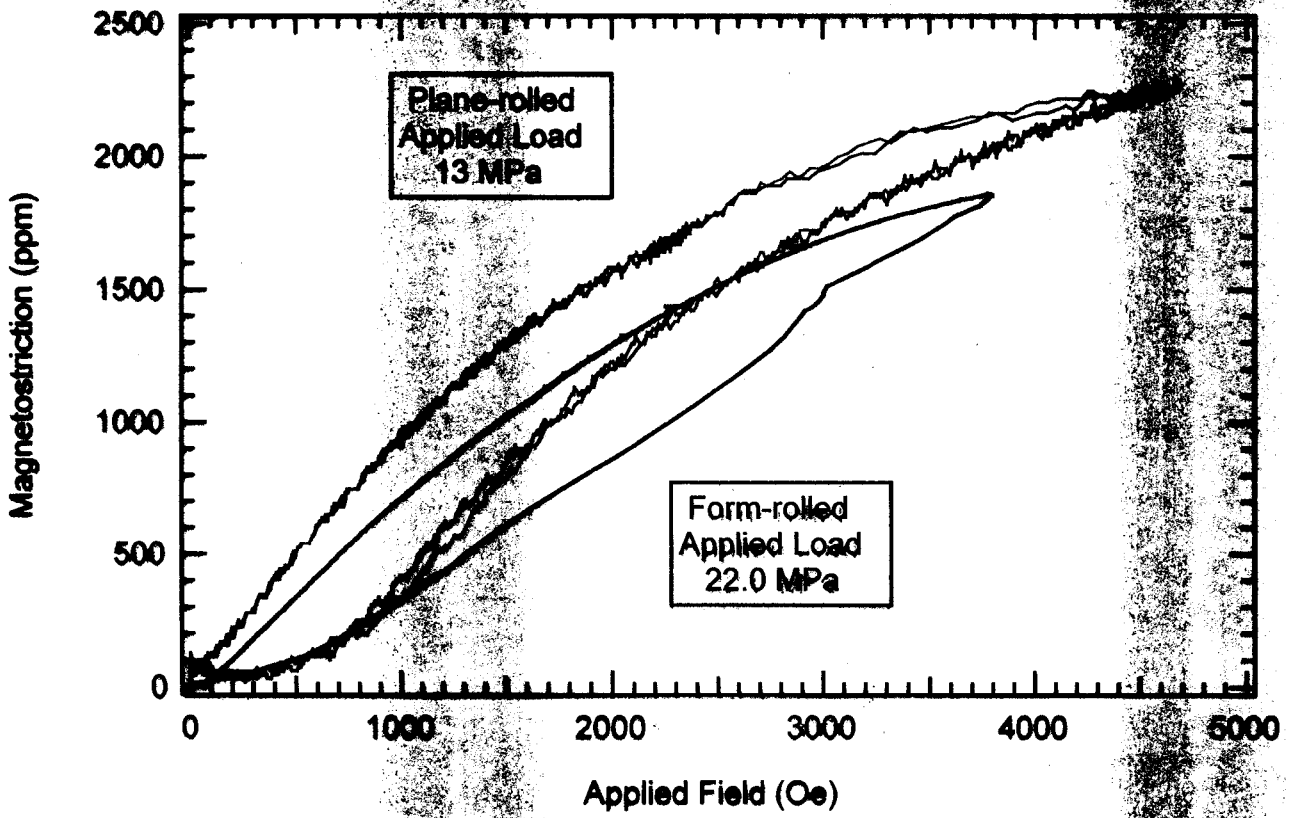
Form-rolled vs. Plane-rolled at 10 K

As expected, even with a higher applied load, the form-rolled specimen exhibits lower magnetostriction than the plane-rolled specimen.



Curve shows 10 K magentostriction

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Magnetostrictive Materials: Future Work

Textured polycrystals will be produced as outlined for various degrees of deformation and the magnetostriction will be measured along the axis which coincides with the rolling direction.

X-ray diffractometry, hardness testing, metallography, and bulk thermal expansion measurements will be used to characterize the microstructure.

Begin to investigate machinable, TbDyZn single crystals

New cryostat for magnetostrictive testing between 4 K and 77 K.

A sealed rod filled with TbDy chunk material will be sent to American Superconductor for a drawing test.

Cycling tests

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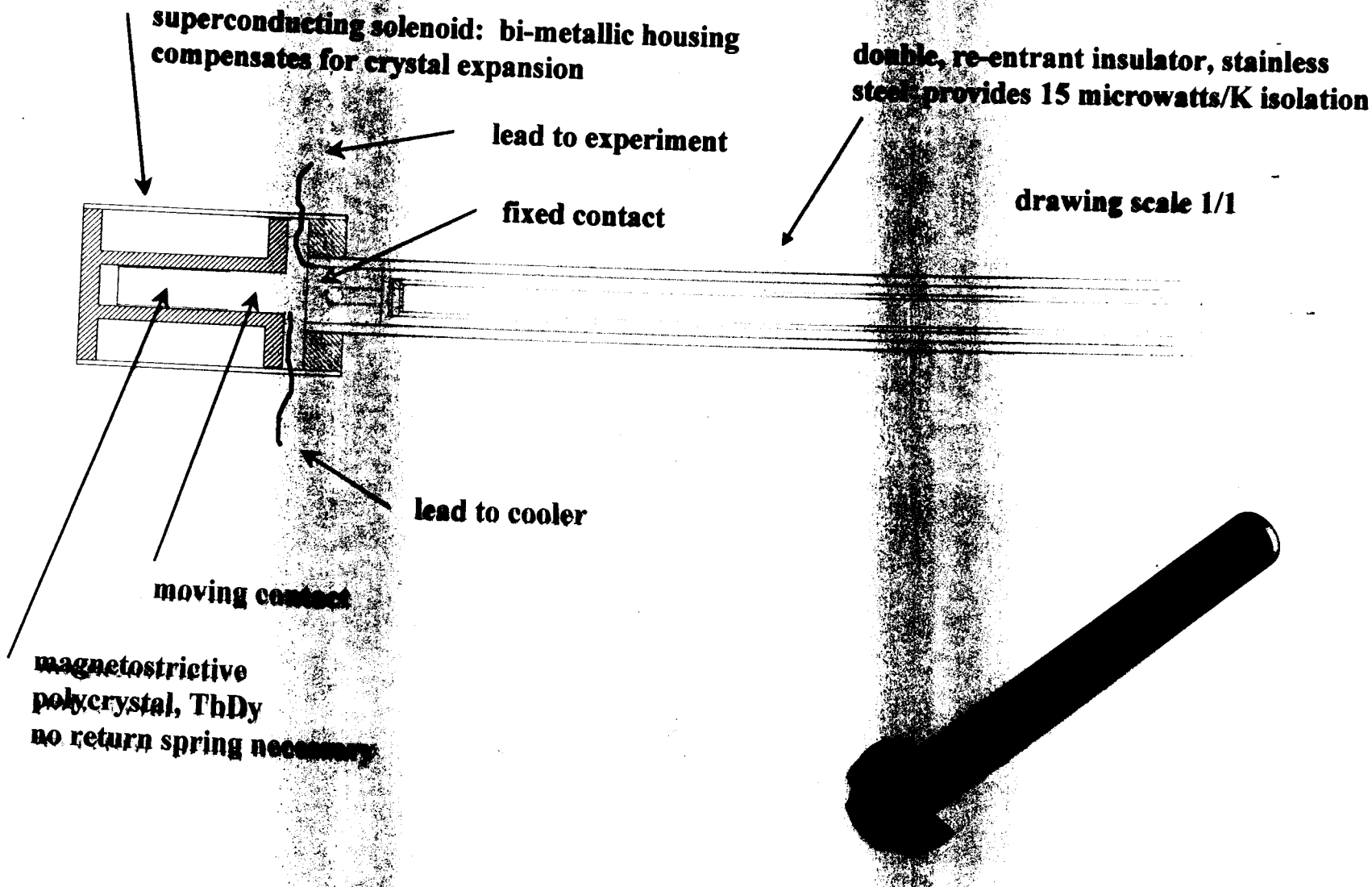
Magnetostrictive, Cryogenic Heat-Switch



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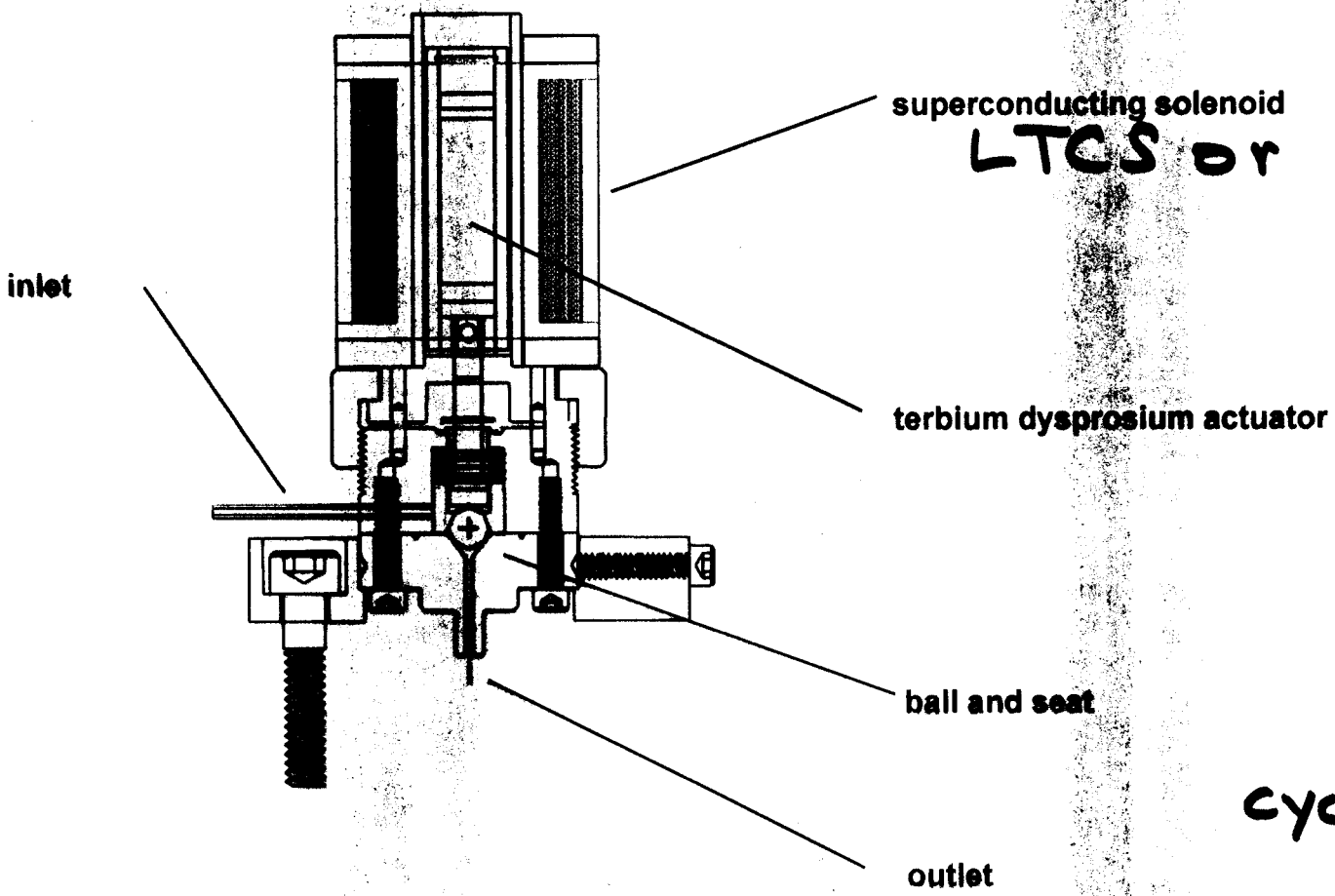
Second Generation Magnetostrictive Superfluid Helium Valve



cycled open & close 300+ times

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