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SHOCK INDUCED MELTING OF SAPPHIRE

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BASIC RELATIONSHIPS

EOS IN VARIABLES ρ, T

$$E=E(\rho,T)=E_x(\rho)+E_T(T)=E_x(\rho)+\int_0^T C_v(\rho,T)dT,\quad P=P(\rho,T)=P_x(\rho)+G(\rho,T)\rho E_T=\rho^2\frac{dE_x}{d\rho}(\rho)+G(\rho,T)\rho\int_0^T C_v(\rho,T)dT.$$

DETERMINATION OF GRUNEISEN FUNCTION

$$\left(\frac{\partial E}{\partial(1/\rho)}\right)_T=T\left(\frac{\partial P}{\partial T}\right)_\rho-P \Rightarrow \left(\frac{\partial TE_T\Gamma}{\partial T}\right)_\rho-2\frac{TE_T\Gamma}{T}=\left(\frac{\partial E_T}{\rho\,\partial(1/\rho)}\right)_T \Rightarrow \Gamma(\rho,T)=\frac{T}{E_T(\rho,T)}\int_0^T\left(\frac{\partial E_T(\rho,T)}{\rho\,\partial(1/\rho)}\right)_T\frac{dT}{T^2}$$

$$\left.\frac{TE_T\Gamma}{T^2}\right|_{T=0}=\lim_{T\to 0}\frac{C_vT\Gamma}{T}=\lim_{T\to 0}C_v\Gamma=0$$

$$\Gamma(\rho,T)=\frac{E_{T0}}{E_T}\frac{T}{T_0}\left(\Gamma_0(\rho)+\left(1-\frac{T}{T_0}\right)\frac{\partial E_{T0}}{E_{T0}\rho\,\partial(1/\rho)}\right)+\frac{T}{E_T}\int_0^T\left(\frac{\partial C_v(\rho,T)}{\rho\,\partial(1/\rho)}\right)_T\frac{dT}{T}-\frac{1}{E_T}\int_0^T\left(\frac{\partial C_v(\rho,T)}{\rho\,\partial(1/\rho)}\right)_T dT$$

SPECIAL CASES

$T>T_0$: $C_v=const$

$$E_T(\rho,T)=E_{T0}(\rho)+C_v(T-T_0)$$

$$\Gamma(\rho,T)=\frac{E_{T0}}{E_T}\frac{T}{T_0}\left(\Gamma_0(\rho)+\left(1-\frac{T}{T_0}\right)\frac{\partial E_{T0}}{E_{T0}\rho\,\partial(1/\rho)}\right)$$

$$\Gamma(\rho)=\Gamma_0(\rho)=\frac{T}{C_vT_0-E_{T0}}\frac{\partial E_{T0}}{\rho\,\partial(1/\rho)}$$

Debye approximation

$$E_T(\rho,T)=Te_T(\theta_D(\rho)/T),\quad C_v(\rho,T)=C_v(\theta_D(\rho)/T)$$

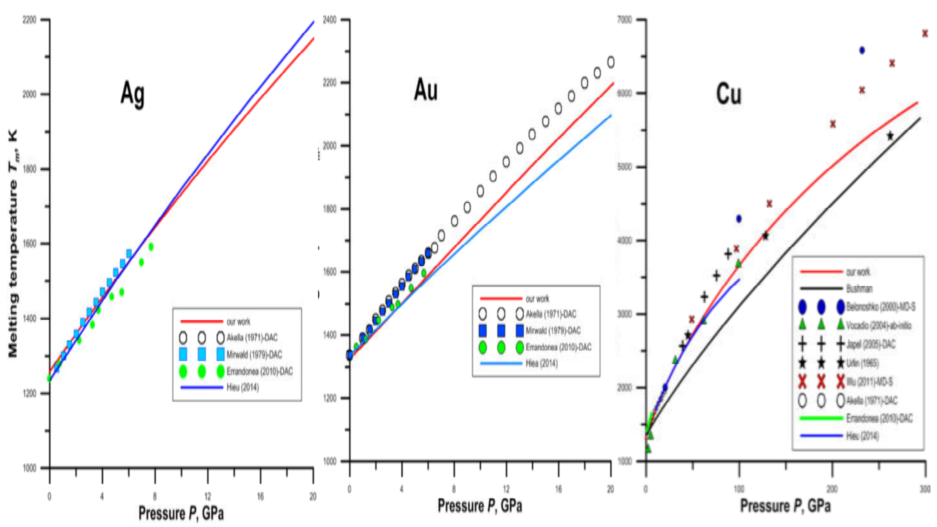
$$\Gamma(\rho)=\Gamma_{00}(\rho)=-\frac{\partial\ln(\theta_D(\rho))}{\partial\ln(1/\rho)}$$

Debye approximation+ el. com.

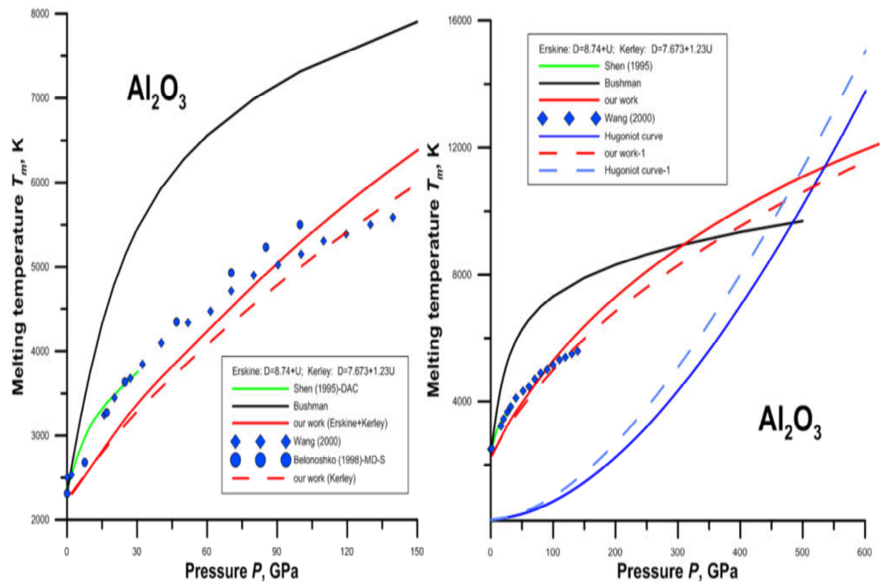
$$E_T=Te_T\left(\frac{\theta_D(\rho)}{T}\right)+\frac{c_eT^2}{2}\left(\frac{\rho_0}{\rho}\right)^{\gamma_e}$$

$$\Gamma(\rho,T)=\frac{T}{E_T(\rho,T)}\left[\Gamma_{00}(\rho)e_T\left(\frac{\theta_D(\rho)}{T}\right)+\gamma_e\frac{c_eT}{2}\left(\frac{\rho_0}{\rho}\right)^{\gamma_e}\right]$$

MELTING CURVES OF SILVER, GOLD AND COPPER



MELTING CURVE OF SAPPHIRE



DETERMINATION OF SPECIFIC COLD ENERGY & GRUNEISEN FUNCTION

$$E-E_0=\frac{1}{2}(P_H(\rho)+P_0)\left(\frac{1}{\rho_0}-\frac{1}{\rho}\right)$$

$$D=\alpha+\beta U \Rightarrow P_H(\rho)=P_0+\rho_0DU=P_0+\rho_0\frac{\alpha^2(1-\rho_0/\rho)}{[1-\beta(1-\rho_0/\rho)]^2}.$$

DEBYYE APPROXIMATION

$$-\frac{dE_x^*}{d(1/\rho)}+\Gamma_{00}(\rho)\rho E_T(\rho,T_H(\rho))=P_H(\rho)$$

COMMON MODEL FOR GRUNEISEN FUNCTION***

$$E_T(\rho,T_H(\rho))=\psi(\rho)-E_x^*\qquad \Gamma_{00}(\rho)=-\left(\frac{2-t}{3}\right)-\frac{1}{2\rho}\frac{\frac{d^2}{d(1/\rho)^2}\left(\rho^{-\gamma}P_x(\rho)\right)}{\frac{d}{d(1/\rho)}\left(\rho^{-\gamma}P_x(\rho)\right)},\quad \gamma=\frac{2t}{3}\ ***$$

$$-\frac{dE_x^*}{d\rho^3}=2\left(\frac{2+t}{3}+\frac{P_H(\rho)-\rho^2dE_x^*/d\rho}{\rho(\psi(\rho)-E_x^*)}-3\right)\left(\frac{d^2E_x^*}{\rho d\rho^2}+(2-\gamma)\frac{dE_x^*}{\rho^2d\rho}\right)+(3-\gamma)(2-\gamma)\frac{dE_x^*}{\rho^2d\rho}$$

$$\left.E_x^*\right|_{\rho=\rho_0}=0,\quad \left.\frac{dE_x^*}{d\rho}\right|_{\rho=\rho_0}=\frac{P_0}{\rho_0^2}-\frac{\Gamma_0E_{T0}}{\rho_0},\quad \left.\frac{d^2E_x^*}{d\rho^2}\right|_{\rho=\rho_0}=-\left.\frac{dP_H}{\rho^2d\rho}\right|_{\rho=\rho_0}-\Gamma_0^2\frac{E_{T0}}{\rho_0^2}-2\left.\frac{dE_x^*}{d\rho}\right|_{\rho=\rho_0}$$

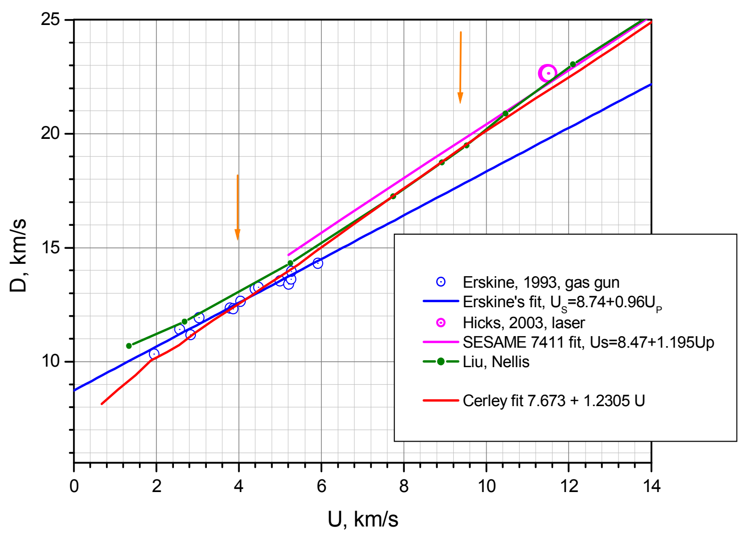
$$\theta_D(\rho)=\theta_{D0}\left(\frac{\rho}{\rho_0}\right)^{\frac{1+t}{3}}\sqrt{\frac{\frac{d}{d\rho}\left(\rho^{-\gamma}P_x\right)}{\left.\frac{d}{d\rho}\left(\rho^{-\gamma}P_x\right)\right|_{\rho=\rho_0}}}\Rightarrow T_H(\rho)\,e_T\left(\frac{\theta_D(\rho)}{T_H(\rho)}\right)=\psi(\rho)-E_x^*(\rho)$$

*** t=0 is Landau and Slater theory, t=1 is Dugleyla and MacDonald hypothesis and t=2 is the theory of free volume

LINDEMANN'S LOW

$$T_{mel}=const\times V^{2/3}\theta_D^2(\rho),\quad \Gamma(\rho)=\Gamma_{00}(\rho)=-\frac{\partial\ln(\theta_D(\rho))}{\partial\ln(1/\rho)}\Rightarrow\frac{\partial\ln(T_{mel})}{\partial V}=\frac{2}{V}\left(\frac{1}{3}-\Gamma(\rho)\right),\ T_{mel}=T_{mel0}\times(\rho_0/\rho)^{2/3}(\theta_D(\rho)/\theta_{D0})^2,$$

SHOCK HUGONIOT OF SAPPHIER



D-U. Kerley's fit is the best approximation of old gas gun data and laser points was used for calculation!

HUGONIOT TEMPERATURE OF SAPPHIRE