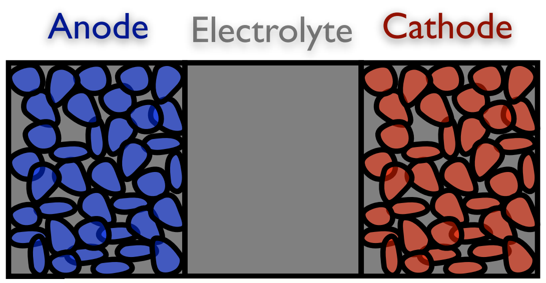
Introduction to the Materials Science of

Rechargeable Batteries

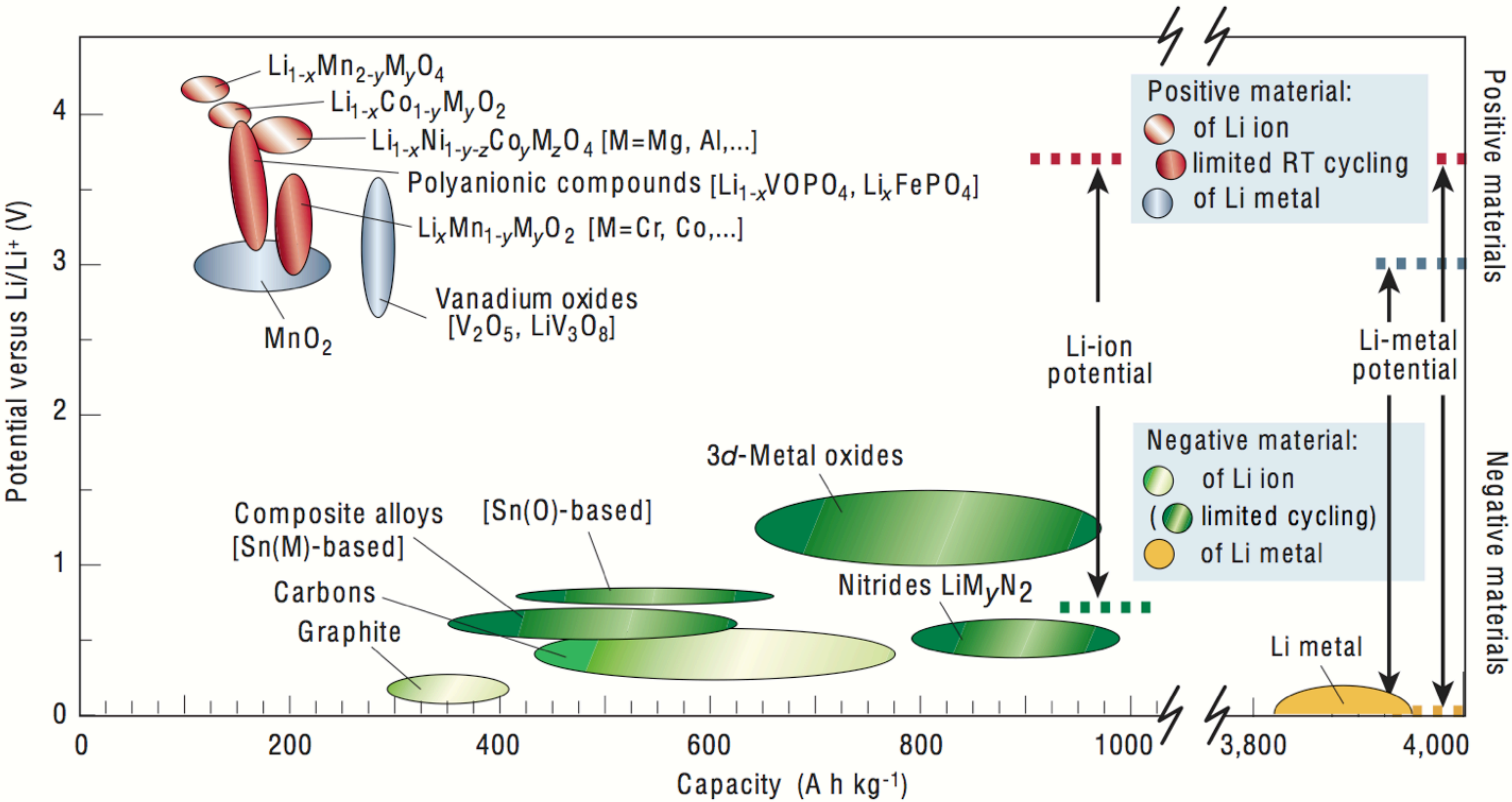
Week 1: Basic Concepts, Fundamentals, and Definitions

Lecture 1.3: Energy and Power in a Battery

By R. Edwin Garcia
Associate Professor of Materials Engineering
Purdue University

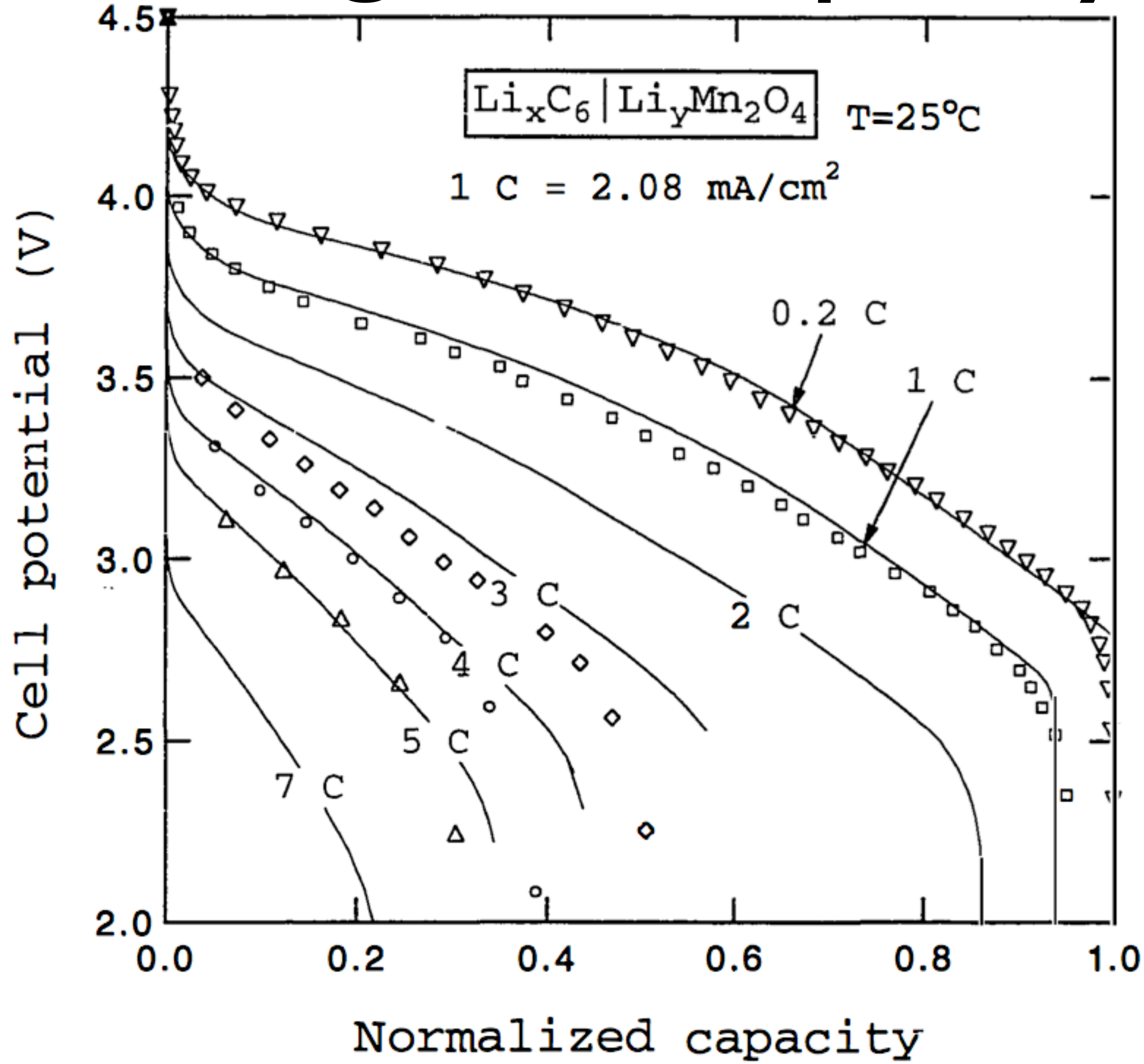


Electrode Materials



J. M. Tarascon and M. Armand. Issues and Challenges Facing Rechargeable Lithium Batteries. Nature, 414:359-367, 2001

The Voltage vs Capacity Plot



(From Mark Doyle's thesis)

Maximum Theoretical Specific Energy

(MTSE)

For an electrode phase

$$MTSE = \frac{xzFE}{W_t}$$

For an entire battery

$$MTSE_B = \frac{\min\{Q_c, Q_a\}(Ec - E_a)}{M_{tot}}$$

Units:

W h/kg

Energy and Energy Density

$$U = \frac{\int_{t_\circ}^{t_f} I(t)E(t)dt}{M_t}$$

For a composite battery:

$$U = \frac{QE_{ideal}}{M_t} = \min\{Q_c, Q_a\}\frac{E_{ideal}}{W_t}$$

$$= \frac{E_c - E_a}{W_t} zFc_T^i(1 - \epsilon_i - \epsilon_f)h_i$$

Power and Power Density

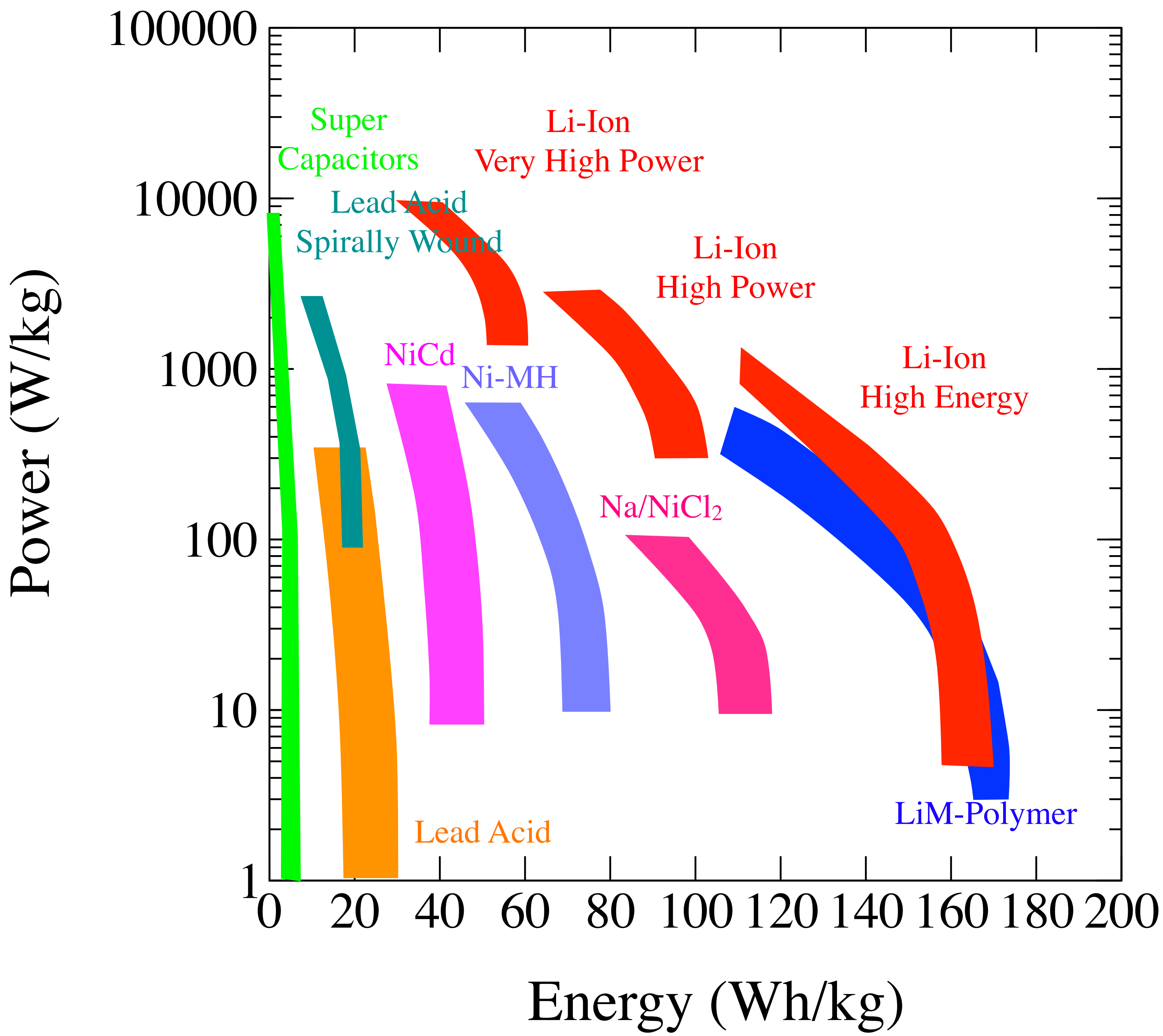
$$P = \frac{\int_{t_\circ}^{t_f} I(t)E(t)dt}{(t_f - t_\circ)M_t}$$

For a composite battery:

$$P = \frac{QE_{ideal}}{W_t(t_f - t_\circ)} = \min\{Q_c, Q_a\}\frac{E_{ideal}}{W_t(t_f - t_\circ)}$$

$$= \frac{E_c - E_a}{W_t(t_f - t_\circ)} zFc_T^i(1 - \epsilon_i - \epsilon_f)h_i$$

Ragone Plot



R. Brodd. Broddside. In Drug Discovery Approach to Breakthroughs in Batteries, Massachusetts Institute of Technology, Cambridge, Massachusetts, 2008.